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ABSTRACT

This course of study specifies the science skills and concepts that are to be taught in the various grades of the Euclid (Ohio) City Schools. Included are instructional objectives for the life, physical, and earth sciences for grades K to 6, suggested field trips and planetarium schedules (by elementary grade levels), and scope and sequence charts for primary and intermediate levels. Also included are instructional objectives for: grade 7 (earth science); grade 8 (life science, honors physical science); grade 9 (introduction to physics and chemistry, introduction to basic science); grades 9 and 10 (honors biology, regular biology); grade 10 (regular biology, basic science); grades 10 and 11 (honors chemistry, regular chemistry); grade 11 (advanced placement chemistry); grades 11 and/or 12 (physics, project physics, biology, advanced placement biology, astronomy, and phase science--elementary chemistry, backpacking biology, greenhouse, environmental pollution and ecology). A scope and sequence chart for grades 7 and 8 science courses is also provided. (JN)

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Graded Course of Study

Science

(K - 12)

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SE044286

Euclid Public Schools
Euclid, Ohio

EUCLID CITY SCHOOLS
EUCLID, OHIO

COURSE OF STUDY
SCIENCE K - 12

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October 1982

TABLE OF CONTENTS

K - 12

SCIENCE GRADED COURSE OF STUDY

Resolution i
Introduction ii
Philosophy iii
Program Goals Statement iv

KINDERGARTEN:

Life Science - Respect for Life 3
Life Science - Plants and Animals 4
Life Science - Health 5
Physical Science - Magnetism, Machines, Sound & Hearing, and Fire & Heat 6
Earth Science - Sun, Planets, Seasons, Weather, and Atmosphere 7

GRADE ONE:

Life Science - Respect for Life 11
Life Science - Plants and Animals 12
Life Science - Health 13
Earth Science - The Earth 14

GRADE TWO:

Life Science - Respect for Life 17
Life Science - Plants 18
Life Science - Animals 19
Earth Science - Weather 20

GRADE THREE:

Life Science - Respect for Life 23
Physical Science - Magnetism and Electricity 24
Physical Science - Heat Sources, Measurements and Changes 25
Earth Science - Space 26

GRADE FOUR:

Life Science - Respect for Life 29
Life Science - Plants and Animals 30
Physical Science - Machines 31
Earth Science - Weather 32

GRADE FIVE:

Life Science - Respect for Life 35
Life Science - Health 36
Earth Science - Oceanography 37
Earth Science - Astronomy, Theories of Origin of Earth 38

GRADE SIX:

Life Science - Respect for Life 41
Life Science - Heredity 42
Life Science - Health (Drugs, Alcohol, and Tobacco) 44
Physical Science - Motion in the Universe 45
Earth Science - Geology 47

EUCLID ELEMENTARY SCIENCE TEACHING UNITS (K-6)
SCOPE AND SEQUENCE:

Primary Levels 51
Intermediate Levels 53

EUCLID ELEMENTARY PLANETARIUM SCHEDULE BY LEVELS 57

EUCLID OUTDOOR MADISON TRIPS BY LEVELS 61

SUGGESTED ELEMENTARY SCIENCE FIELD TRIPS:

Kindergarten 65
Grade One 66
Grade Two 67
Grade Three 68
Grade Four 69
Grade Five 70
Grade Six 71

GRADE SEVEN:

Earth Science 75

GRADE EIGHT:

Life Science 79
Physical Science (Honors) 80

SCOPE AND SEQUENCE (7-8):

Earth Science 83
Life Science 85
Physical Science (Honors) 87

GRADE NINE:

Introduction to Physics and Chemistry 495
Introduction to Basic Science 498 91

GRADES NINE AND TEN:

Biology 492 (Honors)/Regular Biology 404 (Average and Above) 95

GRADE TEN:

Biology 406 (Average and Below) 107
Basic Science 408 119

GRADES TEN AND ELEVEN:

Chemistry 402 (Honors)/414 (Average and Above) 127

GRADE ELEVEN:

Chemistry 411 (Advanced Placement) 137

GRADES ELEVEN AND/OR TWELVE:

Physics 424 (Average and Above) 145
Project Physics 425 (Not Grouped) 163
Biology 451 (Advanced Placement)................................ 171
Biology 454 (Average and Above) 181
Astronomy 464 (Average and Above) 189
Phase Science 45501 and 45502 (Not Grouped):
  Elementary Chemistry 197
  Backpacking Biology 201
  Greenhouse 205
  Environmental Pollution and Ecology 208

GRADE TWELVE:

Physics 421 (Advanced Placement) 221

EVALUATION 237

Regular Meeting
July 12, 1982

RESOLUTION NO. 82-7-281

COURSE OF STUDY
SCIENCE, K-12 - APPROVE

Moved by Mrs. Turek

Seconded by Mrs. Nurmi

RESOLVED that
the Euclid Board of Education adopt the following graded course of study for science, K-12, in compliance with ORC 3313.60.

Copies of the course of study are available in the office of the Director of Instruction.

Ayes:
Mr. Schwegler
Mrs. Turek
Mr. Flowers
Mrs. King
Mrs. Nurmi

Nays: None

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

INTRODUCTION

It is the purpose of this course of study to specify science skills and concepts that are to be taught in the various grades of the Euclid City Schools.

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

PHILOSOPHY

It is the purpose of the science program of the Euclid City Schools to provide students with the kinds of science experiences and skills that will enable them to become informed members of society. It is also our purpose and belief that science skills are best acquired through a synthesis of content and process teaching techniques. These purposes shall be accomplished by exposing students to the broad instructional objectives contained in this course of study.

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

PROGRAM GOALS STATEMENT

The overall goals of our science program (K-12) include a growing understanding of what science is; the importance of major scientific principles and their discovery, understanding and application; the development of competence in the use of methods of science; the development of interests in science; and the recognition of the role of science in daily living.

Knowledge, skills, attitudes, and processes undergird our teaching of science:

1. Knowledge - to develop knowledge of facts, vocabulary, concepts, and principles
2. Skills - to develop the ability to handle materials and to develop the ability to measure, organize, and communicate scientific information
3. Attitudes - to develop curiosity about phenomena in the world and an appreciation for the contributions of science to daily living
4. Processes - to develop the processes of inquiry by which scientific problems and phenomena are explained and/or controlled

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

KINDERGARTEN

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Respect for Life

KINDERGARTEN

The Child Will:

1. Recognize all animals can reproduce themselves and that offspring grow up
2. Recognize animals, like humans, need food, shelter, and humane care
3. Recognize pets as different from animals that live in the wild
4. Recognize pets as animals who depend on people for food, water, shelter, and care

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Plants and Animals

KINDERGARTEN

The Child Will:

1. Begin to identify and classify foods
2. Begin to become aware of plants and animals and their characteristics
3. Learn that plants grow from seeds

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Health

KINDERGARTEN

The Child Will:

1. Be introduced to the concept of a balanced diet
2. Be introduced to the importance of personal hygiene
3. Be introduced to the proper way to care for pets

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Physical Science - Magnetism, Machines, Sound and Hearing, Fire and Heat

KINDERGARTEN

The Child Will:

1. Begin to learn about magnets
2. Be introduced to machines
3. Learn about fire and heat and the need for safety rules
4. Be introduced to the study of sound and hearing

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Earth Science - Sun, Planets, Seasons, Weather, and Atmosphere

KINDERGARTEN

The Child Will:

1. Be introduced to the planetarium
2. Begin to learn about the sun and the planets
3. Begin a study of the seasons
4. Begin a study of weather and atmosphere

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

GRADE ONE

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Respect for Life

GRADE ONE

The Child Will:

1. Recognize pets cannot take care of themselves
2. Recognize pets and animals have feelings like people and experience pain, joy, and other emotions
3. Recognize pets and animals need to be treated with kindness and gentleness

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Plants and Animals

GRADE ONE

The Child Will:

1. Know that all things can be classified as living and nonliving
2. Know that plants and animals are different in size, shape, and texture
3. Know that plants and animals live in many different places
4. Describe ways plants and animals protect themselves
5. Describe different ways that animals move
6. Know that plants may or may not have leaves, flowers, fruits, or seeds

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Health

GRADE ONE

The Child Will:

1. Know that people are similar in many ways
2. Know that people are different in many ways
3. Know that people have different likes and dislikes
4. Know that people require proper nutrition, rest, exercise, good personal hygiene, and shelter to stay healthy
5. Know that people change as they grow
6. Name the four food groups and plan a balanced meal
7. Name different kinds of places in which people live and some materials used to make houses

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Earth Science - The Earth

GRADE ONE

The Child Will.

1. Know environments differ in landscape, climate, plant and animal life
2. Know environments can be classified as mountains, plains, valleys, forests, deserts, and seacoasts
3. Identify characteristics of mountains, plains, valleys, forests, deserts, and seacoasts
4. Know that human activities such as agriculture, industry, and recreation depend upon the environment
5. Name animals and plants found in each region and know how they adapt to that environment

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

GRADE TWO

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Respect for Life

GRADE TWO

The Child Will:

1. Demonstrate the proper methods for holding small animals
2. Demonstrate the proper way various pets should be fed, watered, and cared for
3. Demonstrate the proper way pets should be exercised
4. Demonstrate the proper way pets can be provided adequate space for rest

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Plants

GRADE TWO

The Child Will:

1. Know most green plants need light, soil, water, and air to live and grow
2. Know most green plants have roots, a stem, leaves, flowers, and fruits
3. Name specific functions of the root, stem, leaves, flowers, and fruits
4. Name some foods obtained from the roots, stem, and leaves of plants
5. Tell there are many kinds of fruits
6. Tell ways seeds are dispersed
7. Name ways plants are used by humans: for decoration, erosion control, and food

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Animals

GRADE TWO

The Child Will:

1. Know animals can be classified as amphibians, reptiles, birds, fish, and mammals
2. Describe some characteristics of amphibians, reptiles, birds, fish, and mammals
3. Know that life is a cycle that includes birth, growth, and death
4. Know animals are capable of different activities at different stages in their life cycles
5. Know life processes include food gathering, respiration, excretion, growth, movement, response, and reproduction
6. Know growth is dependent on the life processes
7. Know animals satisfy the life processes in different ways

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Earth Science - Weather*

GRADE TWO

The Child Will:

1. Know weather is a condition of the air at a given time and place
2. Know sunshine, clouds, rain, fog, and wind can be observed
3. Know temperature and wind can be determined
4. Observe how a thermometer measures variations in temperatures
5. Classify clouds by the way they look
6. Distinguish seasons by temperature change, variation in the length of daylight, and the effects on plant and animal life
7. Demonstrate the water cycle
8. Describe seasonal weather changes and how each varies in different areas
9. Describe how weather affects plants, animals, and people

* Correlated with health education implications

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

GRADE THREE

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Respect for Life

GRADE THREE

The Child Will:

1. Review adequate methods for handling, feeding, exercising, and caring for pets
2. Recognize beneficial methods of cleanliness and sanitation for pets
3. Identify the purposes and goals of local animal shelters
4. Visit a local animal shelter, if possible, and discuss the visit with classmates
5. Recognize who a veterinarian is and what medical attention various pets such as dogs and cats may require

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Physical Science - Magnetism and Electricity

GRADE THREE

The Child Will:

1. Identify various types, parts, and functions of magnets
2. Know some materials are attracted by magnets, others are not
3. Know that a magnet has a north and south pole
4. Know that unlike poles of a magnet attract, and like poles repel each other
5. Know that a compass contains a small magnet
6. Know that the earth behaves like a huge magnet
7. Know that all matter is made of tiny particles of electricity called charges
8. Know that objects that gain or lose charges have static electricity
9. Know we use electricity for many purposes
10. Understand that electricity can be dangerous

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Physical Science - Heat Sources, Measurements and Changes*

GRADE THREE

The Child Will:

1. Know matter is anything that has weight and takes up space
2. Know matter exists in three forms: solid, liquid, and gas
3. Know heating and cooling can cause matter to change forms
4. Know melting, evaporation, boiling, condensation, and freezing are form changes of matter
5. Know most matter expands when heated and contracts when cooled
6. Know that a thermometer is an instrument that measures how hot or cold something is in degrees

* Correlated with health education implications

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Earth Science - Space

GRADE THREE

The Child Will:

1. Name and compare the characteristics of the sun and the earth
2. Know that all stars are made of extremely hot gases and give off their own light
3. Know that the moon and planets are seen by reflected sunlight
4. Know that groups of stars called constellations were usually named after people, animals, or objects
5. Know that earth is one of the nine planets in our solar system
6. Know that the nine planets in our solar system revolve around the sun in nearly circular orbits
7. Know many planets have moons revolving around them
8. Know that our moon goes through a series of phases as it orbits the earth
9. Learn that humans have traveled and lived in space

31

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

GRADE FOUR

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Respect for Life

GRADE FOUR

The Child Will:

1. Review the proper handling, feeding, sanitation, and medical care of pets
2. Recognize what it means to tame or accustom animals to household life
3. Recognize the special needs and proper care of small pets
4. Recognize the special needs and care of large pets
5. Be able to recognize the value of kindness in pet care and training

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Plants and Animals

GRADE FOUR

The Child Will:

1. Know a population is a group of plants or animals of the same kind, living in a given area
2. Be able to give the name for a living thing, an organism
3. Know that a population can change in number and appearance over a period
4. Know a population is increased by the reproduction of new members and by the movement of other members into the area
5. Know some ways animals are born
6. Know how flowering plants reproduce
7. Be able to tell how plants reproduce without seeds
8. Know a population is decreased by the death of members and by the movement of members out of the area
9. Be able to tell what problems may occur if there is a population explosion
10. Know that the environment is everything that surrounds and affects an organism's life
11. Be able to name several organisms that no longer exist on earth, and the reasons for their nonexistence
12. Be able to name several organisms that are in danger of disappearing from the earth
13. Know a community is composed of all the plants and animals in a given area
14. Be able to name inhabitants found in a forest and in a pond
15. Be able to describe the process of photosynthesis and the four things plants need for this process

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Physical Science - Machines

GRADE FOUR

The Child Will:

1. Know work is the result of a force moving an object through a distance
2. Know that machines are devices that are used to make work easier by changing the direction of a force applied to an object
3. Understand that levers, inclined planes, pulleys, screws, and wedges are all simple machines
4. Know that complex machines are simple machines arranged in combination to perform a special function
5. Know that machines have brought both improvements and problems to our everyday life
6. Understand the meaning of conservation, the saving of energy

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Earth Science - Weather

GRADE FOUR

The Child Will:

1. Know that weather is the condition of the atmosphere at a given time and place
2. Know that a meteorologist is a scientist who studies the weather
3. Know that weather predictions are future weather forecasts
4. Know weather forecasts are made by interpreting information about humidity, temperature, wind direction, air pressure, and cloud formations
5. Be able to identify three kinds of clouds: cirrus, stratus, and cumulus
6. Know what air pressure is and how it is measured
7. Know what wind is and what causes it
8. Know where the air masses that bring our weather come from
9. Know that to gather information, the weather forecaster uses a variety of tools including maps and satellites
10. Be introduced to simple weather maps
11. Know that hurricanes, tornadoes, thunderstorms, and blizzards are four kinds of violent storms and that they present severe weather conditions
12. Know that weather conditions can affect human health, activities, and emotions

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

GRADE FIVE

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Respect for Life

GRADE FIVE

The Child Will:

1. Review the proper handling, feeding, sanitation, and medical care of pets
2. Relate various methods of kindness used in effectively training various pets
3. If possible, talk to and ask questions of an animal trainer such as one from a dog obedience school
4. Recognize animals, like humans, have a reproductive system
5. Be able to define and explain spaying and neutering
6. Be able to explain the value of having a dog, cat, etc. spayed or neutered
7. Be able to cite local and national figures on pet overpopulation
8. Be able to cite local and national figures on the plight of unwanted pets

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Health

GRADE FIVE

The Child Will:

1. Tell the name given to the parts of the body that pick up information about what you smell, see, hear, taste, and touch
2. Explain how the brain gets messages from each of these organs
3. Tell the name of and describe the parts of each of these organs
4. Explain the purpose of the skeletal system
5. Describe the skeletal system
6. Explain the difference between voluntary and involuntary muscles
7. Name and describe three types of muscles
8. List the needs of your body to function properly
9. Explain how alcohol, drugs, and tobacco can harm your body
10. Explain how groups of organs work together as systems
11. Describe the functions and parts of the digestive, circulatory, excretory, and respiratory system

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Earth Science - Oceanography

GRADE FIVE

The Child Will:

1. Name and describe the five parts of the ocean floor
2. Discuss the forces that shape the ocean floor
3. Classify ocean movements into tides, waves, and currents
4. Explain the cause of these ocean movements
5. Demonstrate how the oceans provide humans with certain natural resources
6. Classify and describe different forms of animal and plant life in the ocean
7. Tell how humans can prevent pollution of the ocean
8. Describe the technology used to explore the ocean

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Earth Science - Astronomy, Theories of Origin of Earth

GRADE FIVE

The Child Will:

1. Explain how humans gather information about the universe
2. Categorize the members of the solar system according to size, structure, atmosphere, and positions in space
3. Discuss several theories explaining the origin of the universe

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

GRADE SIX

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Respect for Life

GRADE SIX

The Child Will:

1. Review the proper handling, feeding, sanitation, and care of pets
2. Review the latest figures on pet overpopulation and the plight of unwanted pets
3. Visit a local animal shelter, if possible
4. Volunteer at a local animal shelter, if possible
5. Relate his/her experiences with an animal shelter to the rest of the class
6. Recognize famous world leaders who advocate animal care and protection
7. Recognize good mental health for an individual comes from the ability to love beyond himself/herself with compassion and concern for all

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Heredity

GRADE SIX

The Child Will:

1. Tell the name of and describe the tiny living parts of which all organisms are made
2. Tell the names for the male and female reproductive cells
3. Tell the name for the process by which reproductive cells join
4. Explain how a flowering plant sexually reproduces itself
5. Tell the word that means the passing of traits from parent to offspring
6. Tell what the experiments with pea plants taught people about the passing of traits to offspring
7. Tell the name for strands of material found in every cell that carry information needed to control the cell's activities
8. Tell a way in which reproductive cells are different from other cells
9. Explain Mendel's experiments in terms of what is presently known about heredity
10. Tell the possible combinations of genes that could result from a cross between two parents
11. Explain why the sex of a person may affect whether or not a trait appears
12. Tell the names of and describe two diseases that are inherited
13. Tell the name for a change in one or more genes that results in a new trait
14. Describe how specific traits can be produced or preserved in plants
15. Give three reasons for the producing of specific traits in farm animals
16. Give two examples that show how genes and environment affect living things

Life Science - Heredity
GRADE SIX

17. Tell the name for and give three examples of the kind of behavior that is not learned

18. Tell the name for patterns of behavior that organisms inherit

19. Give two examples of inherited patterns of behavior

20. Name and give two examples of learning theory that is based on rewards and punishment

21. Give the name for behavior repeated so often that it is performed almost without thinking

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science - Health (Drugs, Alcohol, and Tobacco)

GRADE SIX

The Child Will:

1. Describe the probable factors that lead to drug use or abuse
2. Differentiate between physical dependence and psychological dependence
3. Demonstrate a knowledge of the probable effects of the use or misuse of drugs categorized as depressants, including alcohol
4. Demonstrate a knowledge of the probable effects of the use or misuse of drugs categorized as stimulants
5. Demonstrate a knowledge of the probable effects of the use or misuse of the drugs categorized as hallucinogenic, including marijuana and LSD
6. Tell in his or her own words how a given drug substance might enter the body and affect the body's interdependent behavior
7. Describe habit formation
8. Demonstrate a knowledge of the greatest dangers of cigarette smoking including: lung cancer, emphysema, and heart disease
9. Tell the name of the chemical that is a poison in cigarettes
10. Describe the probable causes of "cigarette cough"
11. Demonstrate a knowledge of other possible physical effects of cigarette smoking on the body

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Physical Science - Motion in the Universe

GRADE SIX

The Child Will:

1. State Isaac Newton's First Law of Motion
2. Tell the word that means the tendency of objects to resist changes in motion
3. Name the force that slows moving things
4. Tell the word to describe how much inertia something has
5. Tell the word for the distance an object travels in a certain amount of time
6. Tell the word that describes how fast and in what direction an object moves
7. Tell the word that describes a change in an object's rate or direction of motion
8. Explain how changing the amount of force that acts on an object changes its acceleration
9. State Newton's Second Law of Motion
10. State Newton's Third Law of Motion
11. Give two examples of Newton's Third Law of Motion
12. Name the forward and upward forces that act on an airplane
13. Tell two ways in which an airplane's forward motion is produced
14. Explain how the upward force on an airplane's wing is produced
15. Name the force that pulls all objects toward each other
16. Tell what things affect the size of the earth's pulling force
17. Compare the rates at which objects of different mass fall to earth

Physical Science - Motion in the Universe
GRADE SIX

18. Describe the force needed to move something in a curved path

19. Tell the name for the path that any object takes as it travels around another path

20. Tell how objects are able to orbit the earth

21. Tell the name for an object that orbits another object in space

22. Tell the name for earth's path around the sun

23. Describe earth's two kinds of motion

24. Tell what prevents the earth from flying out of its orbit

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Earth Science - Geology

GRADE SIX

The Child Will:

1. Describe how rocks are formed from layers of material that settle out of water
2. Name and give three examples of the above type of rock
3. Tell the name for red hot melted rock under the earth's surface
4. Tell the name for red hot melted rock as it comes out of the earth's crust
5. Tell the name of the kind of rock that forms from hot material that cools and hardens
6. Give two examples of the kind of rock named above
7. Tell the name and give two examples of the kind of rock formed from sedimentary and igneous rocks
8. Tell two ways in which the kind of rock named above may be formed
9. Tell the name of the term for the process by which the earth's rock material is mixed and reused
10. List four properties useful in identifying minerals
11. Describe two clues that help identify each of the following: igneous rocks, sedimentary rocks, and metamorphic rocks
12. List three facts about layers of sedimentary rock that help provide us with clues to the earth's past
13. Tell the word that describes whether one object or event is older than another
14. Name two clues that help geologists identify top and bottom layers of rock
15. Tell the name for the tracks, traces, or remains of earlier living things in rock

Earth Science - Geology
GRADE SIX

16. Describe two ways in which traces of living things are made in rock
17. Tell two ways in which the earth's surface is believed to have been different in the past
18. Tell how the kind and variety of life on earth is believed to have changed
19. Describe the fossil evidence that supports the above beliefs
20. Tell the name and give two examples of the kind of fossil that is useful for finding the age of a rock
21. Tell the name for a substance that changes or decays into another substance over a period of time
22. Tell how the kind of substance named above is used to find the age of rocks and of fossils
23. Tell the name of the four main time periods into which the history of the earth is divided
24. Describe the surface of the earth during each division of the earth's past
25. Tell what new forms of life appeared in each of the earth's four main periods of time

GRADED COURSE OF STUDY

TEACHING UNITS

SCOPE AND SEQUENCE

K - 6

EUCLID ELEMENTARY SCIENCE TEACHING UNITS

SCOPE AND SEQUENCE

Primary Levels

MAJOR AREAS	KINDERGARTEN	LEVEL 1	LEVEL 2	LEVEL 3
Earth Science	One visit Introduction to Planetarium 1. Sun and planets 2. Seasons 3. Weather and atmosphere	Where We Live 1. Topography - land forms 2. People - places 3. Having fun	How's the Weather 1. Hot - cold 2. Water - clouds	Our Place in Space 1. Sun, moon, stars 2. Space travel Three visits to Planetarium 1. Rotation and revolution 2. Solar system 3. Space travel
Life Science	Food and Nutrition Plants and Animals (Respect for Life)	(Respect for Life) Looking at Plants and Animals 1. Living-not living 2. Where/how animals live/move 3. Plants/more about plants	Plants 1. Plant needs 2. Plant parts 3. Plant growth (Respect for Life) All Kind of Animals 1. Mammals/birds/fish 2. Amphibians 3. Reptiles-Dinosaurs	(Review Caring for Pets) ⟶
Physical Science	1. Magnetism 2. Machines 3. Sound and hearing 4. Fire and heat	One visit to Planetarium North Star Dippers - Bears	Three visits to Planetarium Observing in each season	1. Magnetism 2. Electricity
Health	1. Personal hygiene 2. Care of pets	Looking at You 1. Growing and changing 2. Nutrition 3. Home		1. Nutrition 2. Heat sources/ measurements/ changes

Integrating Themes
Conservation - Change - Interrelationship
Safety - Time - Measurement - Growth
Balance - Survival
Respect for Life

EUCLID ELEMENTARY SCIENCE TEACHING UNITS
(con't.)

Intermediate Levels

MAJOR AREAS	LEVEL 4	LEVEL 5	LEVEL 6
Earth Science	Tomorrow's Weather One planetarium visit 1. Watching weather 2. Moving/water 3. Weather and people	Ocean Frontier Ocean movements/exploration Exploring the Universe Two planetarium visits 1. Earth - moon 2. Solar system 3. Brightest stars	Geology 1. Three types of rocks 2. Identifying rocks 3. Tracing the earth's history in rocks
Life Science	Animal & Plant Communities 1. Green plants 2. Food cycle/path of food 3. Communities and people (Respect for Life) Animal & Plant Populations 1. Living things 2. Size, survival, change	Your Body 1. Staying alive Food - health Digestion - circulation 2. See below (Health)	
Physical Science	Machines 1. Machines and work 2. Machines with wheels 3. Energy		Motion in the Universe Three planetarium visits 1. Making things move 2. Forces 3. Curved motion Moon Zodiac constellations Space colonies
Health	Tomorrow's Weather (See Earth Science) Weather and People	Your Body (See Life Science) 2. Sensing and moving Art of Personal Living (18 weeks)	(Respect for Life) Drugs, Alcohol, and Tobacco Heredity 1. Reproduction 2. Passing of traits 3. Environments and learning

Integrating Themes
Conservation - Change - Interrelationship
Safety - Time - Measurement - Growth
Balance - Survival
Respect for Life

GRADED COURSE OF STUDY

PLANETARIUM SCHEDULE

K - 6

EUCLID ELEMENTARY PLANETARIUM SCHEDULE BY LEVELS

Grade	
KINDERGARTEN	One Visit Awareness of the universe, the sun, and stars
ONE	One Visit Northern sky, dippers, and bears Children encouraged to view the night sky
TWO	Three Visits Constellations and the universe Children encouraged to view the night sky
THREE	Three Visits Rotation and revolution, solar system, and space travel
FOUR	Three Visits 2 - Mythology: Language Arts; Science; Social Studies 1 - Weather: Our changing seasons
FIVE	Two Visits Solar system Planets - brightest stars
SIX	Three Visits Motion in the universe, making things move, curved motion, moon, zodiac constellations, and space colonies

GRADED COURSE OF STUDY

OUTDOOR MADISON TRIPS

BY LEVELS

OUTDOOR EDUCATION TRIPS TO MADISON SITE

Fall Trips (Sept. to Nov.)

Grade Levels: K, 3, 4, 6, and Special Education
Elementary and Junior High Schools

One Autumn Trip

Spring Trips (May and June)

Grade Levels: 2, 4, and Special Education
Elementary and Junior High Schools

One Spring Trip

Senior High science classes scheduled to correlate with biology classes

Both Fall and Spring

GRADED COURSE OF STUDY

FIELD TRIPS

K - 6

SUGGESTED SCIENCE FIELD TRIPS

KINDERGARTEN

Field Trip	Purpose
Cleveland Health Museum	To study the five senses, dental health, and general health
Cleveland Zoo	To study animals and their behavior
Fazios Grocery Store	To study food and nutrition
Natural History Museum	To enjoy a special presentation of animals
Sea World	To study animals of the sea and their habits
Holden Arboretum	To study plants and animals in their natural habitat
	To acquire an appreciation for nature
NASA - Hopkins Airport	To develop an interest in space and air travel
Fire Station and Police Station	To introduce fire and police safety

SUGGESTED SCIENCE FIELD TRIPS

GRADE 1

Field Trip	Purpose
Brunsman Fruit Farm, Geneva	To learn about fruits, how they grow, and how to care for them
Cleveland Aquarium	To observe the behavior of fish and other aquatic animals
Cleveland Greenhouse	To enjoy the beauty of exotic trees, plants, and flowers
Cleveland Health Museum	To study nutrition and good health habits
Cleveland Zoo	To study animals and their behavior
Farms in Autumn or Spring	To observe and learn about farm animals; their behavior and care
Holden Arboretum	To observe seasonal changes and bird migration
Metropolitan Park	To learn about nature
Natural History Museum	To learn about animals
N.A.S.A.	To introduce and create an interest in space
Sea World	To study fish in coral, kelp; food chains and sea lions
Sims Park, Euclid	To study nature first-hand
Shaker Lakes, Shaker	To study nature first-hand

SUGGESTED SCIENCE FIELD TRIPS

GRADE 2

Field Trip	Purposes
Cleveland Aquarium	To study fish and other aquatic animals and their habits
Cleveland Health Museum	To study nuitrition, the human body and its proper care
Cleveland Zoo	To study animals, their characteristics, and habits
Community facilities	To become familiar with and to study the operation of equipment and facilities at the fire station, police station, and post office
Metropolitan Park	To study wild flowers, plants and tree identification
Natural History Museum	To study dinosaurs, rocks, and fossilized animals
N.A.S.A.	To become familiar with the latest developments in space
Orchard Hills Apple Orchard (Fall)	To learn about fruits and their care
Sea World	To study fish, their environment, and habits

SUGGESTED SCIENCE FIELD TRIPS

GRADE 3

Field Trips	Purposes
Cleveland Aquarium	To study nature's food chain
Cleveland Health Museum	To study the five senses, nutrition, and dental health
Shaker Lakes Nature Center	To study nature's provisions
N.A.S.A.	To study latest developments in the space program

SUGGESTED SCIENCE FIELD TRIPS

GRADE 4

Field Trips	Purpose
Cleveland Health Museum	To study good health habits
Natural History Museum	To study the endangered species, food chains, and natural habitats of animals
National Weather Bureau, Cleveland Hopkins Airport	To study forecasting weather and methods of forecasting
N.A.S.A.	To study weather forecasting, weather balloons, utilizing natural resources, wind power, and solar energy

SUGGESTED SCIENCE FIELD TRIPS

GRADE 5

Field Trip	Purpose
Cleveland Health Museum	To study human growth and development

SUGGESTED SCIENCE FIELD TRIPS

GRADE 6

Field Trip	Purpose
Cleveland Health Museum	To become aware of and to explore the similarities of people with emphasis on physical, emotional, and mental handicaps which create differences To explore drugs, alcohol, and tobacco. To observe exhibits and specimens, showing the effects on a person's mental, physical, and emotional health To explore human heredity, introducing basic human genetics, emphasizing how traits are inherited through genes and chromosomes
Holden Arboretum	To study plants and animals
Waste and Water Treatment Plant, Euclid	To study pollution
Sea World	To study pollution and ecology
Natural History Museum	To study rock formations

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

GRADE SEVEN

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Earth Science

GRADE SEVEN

Instructional Objectives

A. Students should gain an understanding that studies of the universe lead to knowledge about earth and its place in the universe, and that observation and experimentation are the bases of the scientific reasoning which lead to logical conclusions

B. Students should gain an understanding that earth science is a study of the constantly changing earth, its material, and the processes by which changes are brought about. Changes affect crustal materials, land forms, rock structures, and life itself

C. Students should gain an understanding that a study of earth materials ranges through all phases of matter, from sub-atomic particles through minerals, rocks, and rock bodies

D. Students should gain an understanding that some processes causing changes in the earth's crust are surface phenomena; others are interior processes

E. Students should gain an understanding that some changes are related to chemical cycles in which elements form new combinations which depend upon temperature, pressure, and the availability of other elements

F. Students should gain an understanding that some changes are related to the rock cycle in which weathering, erosion, and burial bring about different mineral combinations and form different rock types

G. Students should gain an understanding that air and water have a direct bearing on physical and chemical changes in the surface matter of the earth

H. Students should gain an understanding that processes which change the face of the earth have operated in the past as they operate in the present and as they will operate in the future

I. Students should gain an understanding that the atmosphere, hydrosphere, lithosphere, and biosphere are in delicate balance so that changes in one are reflected by changes in the others

J. Students should gain an understanding that examination of the earth's crust and the organic remains it holds, helps provide an understanding of the earth's history

Earth Science
GRADE SEVEN

K. Students should gain an understanding that humans are responsible for many changes in the earth which influence our environment and use earth's resources

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

GRADE EIGHT

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Life Science

GRADE EIGHT

Instructional Objectives

A. Students should gain an understanding that life science consists of science product: facts, hypotheses, and theories, and science process: methods of scientific inquiry such as observation, experimentation, and theorizing

B. Students should gain an understanding that an organism's life activities are dependent on the organism's structure and organization

C. Students should gain an understanding that organisms are inter-related with each other and with their physical environment

D. Students should gain an understanding that changes have occured in living things through time. Many species alive in the past have disappeared and many species alive today were not present in the past

E. Students should gain an understanding that life begets life. Organisms inherit traits from their parents and these traits are modified by environment

F. Students should gain an understanding that similarities and differences in structure and function are used to classify and interpret living organisms

G. Students should gain an understanding that an organism's survival is based on adaptation to its environment

H. Students should gain an understanding that humans have interfered with natural biological processes to their advantage and to their detriment

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Physical Science (Honors)

GRADE EIGHT

Instructional Objectives

A. Students should gain an understanding of chemistry and physics and their relationship to each other

B. Students should understand the relationships and uses of the periodic chart of the elements

C. Students should gain an understanding of the mathematical relationships involved in physical and chemical changes

D. Students should gain an understanding of relationships involved in chemical and physical changes

E. Students should gain insight into scientific reasoning, using accepted scientific laws of principles

GRADED COURSE OF STUDY

SCOPE AND SEQUENCE

7 - 8

SCIENCE

Earth Science

SCOPE AND SEQUENCE

Topics: / Concepts:	Scientific Reasoning	Earth Changes	Earth Materials	Earth Processes	Interactions	Rock Cycles	Geohistory	Crust	Resources
Universe	X		X		X		X		
Solar System	X				X		X		X
Earth - Moon	X			X	X		X		X
Crust - Matter	X	X	X	X		X	X	X	X
Minerals	X	X	X			X	X	X	X
Igneous Metamorphic	X	X	X	X		X	X	X	X
Sedimentary	X	X	X	X		X	X	X	X
Erosion, Running Water	X	X		X	X	X	X	X	X
Erosion, Arid	X	X		X	X	X	X	X	X
Glaciers	X	X		X			X	X	
Maps	X					X	X		
Earthquakes	X	X			X	X		X	
Geography	X			X		X	X		
Time	X	X		X	X	X	X		
Atmosphere	X		X	X	X				
Weather	X			X	X	X		X	
Hydrosphere	X		X	X	X	X	X	X	X
Coasts & Currents	X	X		X	X	X		X	X
Pollution	X	X	X			X			X
Natural Resources	X		X			X	X		X
Energy Resources	X		X				X		X

SCIENCE

Life Science

SCOPE AND SEQUENCE

Topics: \ Concepts:	Scientific Reasoning	Form and Function	Inter-relations	Biochange	Reproduction, Inheritance	Classification	Adaptation, Homeostasis	Human Ecology
Measurement	X							
Structure & Composition	X	X				X	X	
Cells	X	X	X				X	
Tissues	X	X	X					X
Behavior	X	X	X	X	X			
Plants	X	X				X		
Photosynthesis	X	X						X
Bacteria & Viruses	X	X	X			X		X
Protozoa	X	X	X			X		X
Algae & Fungi	X	X	X			X		X
Disease	X	X	X	X	X		X	
Skeleton	X	X					X	
Circulation	X	X					X	
Nervous System	X	X					X	
Nutrition	X	X			X		X	X
Chemical Abuse	X	X			X		X	X
Reproduction	X	X		X	X			X
Selection	X			X	X		X	X
Genes & Traits	X	X		X	X			X
Population Growths	X			X	X			X
Resources	X			X				X

SCIENCE

Physical Science (Honors)

SCOPE AND SEQUENCE

Topics: \ Concepts:	Scientific Reasoning	Patterns, Laws Classification	Structure, Properties	Changes, Variables	Physical Laws, Energy	Knietic Theory	Technological Development	Resources
Measurement	x	x			x	x		
Force & Work	x			x	x	x		
Motion	x					x	x	
Chemical-Physical Change	x	x	x	x	x	x	x	x
Atoms & Compounds	x	x	x			x		x
Phases	x		x	x		x	x	
Periodic Table	x	x			x			
Chemical Families	x	x	x					x
Organic Chemistry	x	x	x	x				x
Solutions	x	x	x					
Chemical Reactions	x				x	x	x	
Acids, Bases & Salts	x	x	x					
Heat	x	x		x	x	x	x	
Waves, Radiation	x			x	x	x	x	
Optics	x						x	
Electricity	x	x		x	x	x		
Electronics	x	x	x	x	x	x	x	
Nuclear	x		x		x		x	x

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

INTRODUCTION TO PHYSICS AND CHEMISTRY 495
INTRODUCTION TO BASIC SCIENCE 498

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Introduction to Physics & Chemistry 495
Introduction to Basic Science 498
GRADE NINE

This elective course offers one credit toward graduation. Upon successful completion of the course, the student will demonstrate an understanding of the following:

Instructional Objectives

A. Students should gain an understanding that studies of physical phenomena lead to knowledge about the physical laws of the universe. Observation and experimentation are the basis of the scientific reasoning which leads to logical conclusions

B. Students should gain an understanding that physical science is a study of the classification, structure, patterns, and changes in matter, and the relationship between matter and energy. Physical laws explain the relationship between matter and energy

C. Students should gain an understanding that all matter has definite structure. Elements have predictable physical and chemical properties related to their atomic structure

D. Students should gain an understanding that some changes in matter are related to physical and chemical properties. The major phases and the changes in phase of matter are directly related to temperature and pressure variables

E. Students should gain an understanding that force, work, and motion are related to the physical laws which govern the universe

F. Students should gain an understanding that properties of matter are affected by the gain or loss of heat, the kinetic energy of molecules

G. Students should gain an understanding that many technological developments utilize the wave properties of heat, light, and sound

H. Students should gain an understanding that the effective use of electrical and nuclear energy is directly linked to human resourcefulness

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

BIOLOGY 492/404

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Biology 492 Honors
GRADE NINE
Regular Biology 404
Average & Above
GRADE TEN

This elective course offers one credit toward graduation. Upon successful completion of the course, the student will demonstrate an understanding of the following:

I. Instructional Objectives

A. The basic features of life common to all living things

B. How a scientist conducts an investigation and the features of the system used to make measurements

C. Chemistry and physics and their relationship to the study of living things

D. The structures and functions of cells

E. The incorporation and use of energy by organisms

F. The present and past beliefs concerning how living things reproduce themselves

G. Genetics and the methods used to determine genotypes and phenotypes of parents or offspring when knowledge of one or the other is available

H. The chromosomal basis of heredity and the development of genetics since Mendel's time

I. The chemical basis for the transmission of traits and the features of genes and their chemical structure

J. The patterns of reproduction found in living things

K. Embryology and the changes through which an organism obtains a final form

L. Evolution, the causes of changes in population gene pools, and how a biologist studies relationships among organisms and their ancestors as evidence supporting the theory of evolution

M. Evolution of adaptations and of new groups of organisms

N. Development and use of a universal system of classification

Biology 492/404
GRADES NINE AND TEN

O. The protist kingdom and the basic features of the major groups of organisms in this kingdom

P. The plant kingdom and the basic features of the major groups of organisms in this kingdom

Q. The animal kingdom and the basic features of the major groups of organisms in this kingdom

R. Digestion as it occurs in complex and simple organisms

S. The transport system as it exists in various types of organisms

T. The process of respiration and excretion as they occur in various organisms

U. The structure and function of skeletal and muscular systems and their relationships to protection, support, and locomotion

V. How many of the functions of an organism are directed by chemical control systems

W. The nervous system and its functions in animals of varying complexity

X. The patterns of responses made by organisms to stimuli of their environment

Y. The factors which affect the growth of population

Z. Biotic and abiotic factors which affect an ecosystem

AA. Ecological succession and the features and distributions of the worlds various biomes

BB. The biological background of modern human beings and the ways their special adaptations have influenced their present role in nature

CC. The place of humans in the biosphere and how human influence on the environment can affect the destiny of humans and other organisms

II. Course Outline

A. Metrics
   1. Basic units of measurement
   2. Conversions between subunits
   3. Prefixes

B. Scientific method
   1. Steps in the scientific method
   2. Use as problem solving approach

C. Cells
   1. Elements of the cell theory
   2. Cell organelle structures and functions
   3. Cell organization cells to tissues, to organs, to organ system, to organism
   4. Cell functions: osmosis, diffusion, and active transport

D. Chemistry
   1. Bonding
   2. Formulas
   3. Respiration (aerobic and anerobic)
   4. Basic compounds of protoplasm
   5. Dehydration synthesis and hydrolysis
   6. Enzymes
   7. Photosynthesis
   8. ADP/ATP
   9. DNA structure and replication
   10. DNA and protein synthesis
   11. Mutation
   12. Antibody-antigen reaction system
   13. Biochemical theory of evolution
   14. Hormones
   15. Neurotransmitters

E. Ecology
   1. Definition of ecology
   2. Biotic and abiotic factors of the environment
   3. Feeding groups (herbivores, carnivores, omnivores, parasites, and saprophytes)
   4. Energy pyramid
   5. Nitrogen cycle
   6. Mutualism and commensalism
   7. Succession and the climax community
   8. Types of biomes
   9. Population ecology
   10. Pollution and conservation

F. Reproduction
   1. Cell reproduction (mitosis and meiosis)
   2. Difference between sexual and asexual reproduction
   3. Alternation of generation
   4. Reproductive structures and their functions (flower)
   5. Development from flower, to seed, to fruit
   6. Seed dispersal mechanisms
   7. Structures and functions of the shelled egg
   8. One and two egg twins
   9. Embryonic development
   10. Life cycles

G. Darwin, Lamarck, and the theory of evolution
   1. Evidence in support of and problems with the theory of evolution
   2. Lamarck and the theory of use and disuse
   3. Darwin and the theory of natural selection

H. Taxonomy and classification
   1. Linnaeus and his system of classification
   2. Basis for classification
   3. Classification groups
   4. Primary characteristics of the following kingdoms: protist, animal, and plant
   5. Key construction and use

I. Viruses, protists
   1. Virus structure
   2. Virus reproduction and cell destruction
   3. Major groups of protists and basis for classification

J. The microscope
   1. Structures and functions of the microscope
   2. Microscopic measurement
   3. Techniques of slide preparation
   4. Viewing techniques
   5. The microscope as a tool of investigation

K. Digestion
   1. Basic food groups and end products of digestion
   2. Peristalis
   3. Alementary canal
   4. Major organs of the human digestive system and the function of each
   5. Digestion as a chemical process

L. Plant anatomy and function
   1. Major basis for classification (vascular tissue)
   2. Structures of the root, stem, and leaf and their functions
   3. Coordination of the structures in the food making process

M. Kidney an homeostasis
   1. Need for nitrogenous waste elimination
   2. Need for water balance and the function of the kidney
   3. The kidney as an organ of excretion
   4. Nephron: structure and function

N. Hormones
   1. Function of hormones
   2. Human endocrine glands: structure and function
   3. Plant hormone auxin
   4. Plant hormone gibberellin

O. Nerves, muscles, and skeleton
    1. Neuron: structure and function
    2. Reflex arc
    3. Major branches of the nervous systems and their function
    4. Synapse and neurotransmitters
    5. Muscle cells: structure and function
    6. Functions of a skeletal system
    7. Advantages and disadvantages of both an endo and exoskeleton

P. Heredity
    1. Mendel's laws
    2. Related terms
    3. Problem solving involving mono and dihyrid crosses
    4. Human genetic diseases (hemophilia, color blindness, Down's syndrome, sickle cell anemia)
    5. Sex linkage
    6. Nondisjunction

Q. Behavior
    1. Imprinting
    2. Animal communications
    3. Pheromones and behavior
    4. Territoriality

III. Concepts to be Taught

A. Metrics - scientific method
    1. Explain why metrics is useful
    2. Demonstrate the use of the scientific method as a problem solving tool
    3. Identify the need for control in the scientific method
    4. Demonstrate hypothesis formation and testing

B. Cells
    1. Explain that while cells vary in size and shape, all cells have much in common
    2. Identify form as related to function
    3. Explain the how and why of osmosis, diffusion, and active transport
    4. Identify that the cell theory, like many scientific investigations, occured over a period of time with the contributions of many
    5. Explain that each structure within a cell contributes to the functioning of the cell

C. Chemistry
    1. Explain that the study of biology has received much from the other sciences
    2. Explain the "lock and key" theory of enzyme function
    3. Describe the process of photosynthesis
    4. Discuss ATP and ADP (their formation and use in energy transfer)
    5. Describe DNA and the process of protein synthesis
    6. Discuss mutations (how they are formed and why they are important)

7. Describe the antibody-antigen reaction system, how it functions, and why it is important
8. Explain the biochemical theory of evolution and problems with same

D. Ecology
1. Explain that organisms within a community live in a close balance with other organisms of the community
2. Explain that altering the abiotic (nonliving) factors of the environment has a direct affect on the biotic (living) factors within a community
3. Explain that within a community there is a network of inter-relationships between organisms
4. Discuss succession as an orderly process of change within a community
5. Compare and contrast the pyramids of numbers and biomes and relate them to the pyramid of energy
6. Compare the different biomes in terms of the differences in their abiotic factors
7. Describe how decomposed materials are recycled in the community
8. Discuss population ecology
9. Describe the threats to the natural forests and the conservation practices used to preserve forests

E. Reprouduction and embryology
1. Describe cell reproduction (mitosis and meiosis), and explain how the processes result in genetic continuity
2. Compare and contrast the processes of mitosis and meiosis
3. Explain why meiosis and reproduction involving meiosis results in a better chance for survival in the event that changes occur in the environment
4. Identify the relationship between the number of young produced and their individual survival chances
5. Identify the types of fertilization and development and their effects on survival chances
6. Compare and contrast methods of asexual reproduction
7. Compare and contrast shelled egg development in warm blooded animals and cold blooded animals
8. Describe the series of events that occur on a cellular level from the point of conception until cells become specialized (morphogenesis)
9. Compare the amount of parental care and the individual survival chances of the young

F. Darwin, Lamarck and evolution
1. Identify evolution as change and cite examples of change within a living community
2. Explain changes in the natural community as Darwin would by using his theory of natural selection
3. Explain changes in the natural community as Lamarck would by using his theory of use and disuse
4. Describe the process of evolution of a species

5. Describe the process of adaptive radiation
6. Describe the process of convergence
7. Describe the series of events that lead to industrial melanism and how this might be used as support for the theory of natural selection

G. Taxonomy, classification, and key construction
   1. Identify similarities in structure and function as the primary basis for all classification
   2. Explain the need for a third kingdom
   3. Identify major characteristics that subdivide all living things in the following kingdoms: plant, animal, protists
   4. Identify characteristics used to define major divisions of each of the kingdoms listed above
   5. Describe forms of body symmetry and their use in classification
   6. Construct "keys" for the identification of various groups of organisms

H. Viruses, protists, and microscopy
   1. Describe the process of virus transduction
   2. Identify characteristics that separate these life forms from others
   3. Explain what is meant by the phrase "you never really lose a virus"
   4. Explain why many scientists do not define viruses as living organisms
   5. Compare and contrast life functions of the viruses and other organisms
   6. Compare and contrast vaccines and interferon as means of fighting viruses and diseases caused by viruses
   7. Calibrate a microscopic field and use it for measurements of length and rate of speed of organisms as they travel through it

I. Digestion
   1. Compare and contrast the digestive process in a variety of living things
   2. Identify digestion as the breakdown of food into simpler products usable by the cells
   3. Describe the process of enzyme action in digestion
   4. Describe the process of peristalsis and its importance

J. Animal transport and respiration
   1. Compare and contrast the process of transport in a variety of living things
   2. Describe the workings of the antibody-antigen reaction system
   3. Compare and contrast the functions of the gill, trachea, and lungs
   4. Discuss the function of the guard cell in plant photosynthesis and respiration
   5. Describe the transport system as a link between the cells of an organism and its environment
   6. Describe the cohesion-tension theory and its relationship to plant respiration
   7. Compare and contrast respiration in plants and animals

K. Plant anatomy
  1. Identify vascular tissue as a major basis for plant classification
  2. Identify specialized structures and their functions within the root, stem, and leaf
  3. Describe how the specialized structures within a root, stem, and leaf contribute to the processes of photosynthesis and respiration
  4. Describe the process of transpiration and its importance

L. Kidney homeostasis
  1. Explain the importance of water balance within an organism and relate this to kidney function
  2. Compare and contrast the "kidney function" in representative animal groups
  3. Describe how homeostasis is maintained by chemical and nervous systems
  4. Compare and contrast the process used by fresh water and salt water organisms in maintaining proper water balance and in removing waste materials
  5. Discuss the function of the nephron

M. Hormones
  1. Describe the hormonal control hypothesis
  2. Compare and contrast body controls brought about by hormones and the nervous system
  3. Explain the relationship between the hypothalamus and the anterior pituitary gland and suggest reasons why the hypothalamus might be the master gland
  4. Describe the function of hormones in metamorphosis
  5. Discuss the function of the plant hormone auxin and its relationship to tropism

N. Nerves, muscles, skeleton
  1. Describe the process of neurotransmission
  2. Identify the series of events that occur as impulses travel across a synapse
  3. Relate the structure of the neuron to its function
  4. Describe the reflex arc and relate its function to survival
  5. Explain the sliding filament theory and relate this to muscular contraction and movement
  6. Compare and contrast the endo and exoskeleton identifying advantages and disadvantages of each
  7. Compare and contrast the need for support in aquatic and land organisms
  8. Compare and contrast the activities of organisms with and without skeletal systems
  9. Identify the relationship between the amount and kind of intercellular substance and the ability of tissue to lend support
  10. Compare and contrast locomotion in a variety of organisms and relate this function to their muscular and skeletal systems

O. Heredity
   1. Demonstrate an understanding of probability and Mendelian genetics by successfully determining genotypic and phenotypic relationships of specific mono and dihybrid crosses
   2. Explain how Mendel arrived at his laws of dominance, segregation, and independent assortment
   3. Demonstrate genetic problem solving ability by using both the product rule method and the Punnett square methods
   4. Describe the process of nondisjunction and its effects
   5. State and explain the chromosomal theory of heredity
   6. Describe the process of crossing over and explain how it increases the variety within a gene pool
   7. Describe the interrelationship between heredity and environment in the expression of genetic traits

P. Behavior
   1. Distinguish between behavior and psychobiology
   2. Explain the relationship between the complexity of an organism and the complexity of its behavior
   3. Describe behavior controlled by a "biological clock"
   4. Describe the learning pattern called imprinting
   5. Describe pheromones and cite examples of their function
   6. Compare and contrast territoriality in a variety of animals

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

BIOLOGY 406

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Biology 406
Average and Below
GRADE TEN

This elective course offers one credit toward graduation. Upon successful completion of the course, the student will demonstrate an understanding of the following:

I. Instructional Objectives

  A. A greater exchange of ideas and feelings between themselves and the teacher by attempting to develop an awareness of self and of others, as well as fostering improved communications and listening skills

  B. The role of the individual in society and the interaction of the individual with traditions, institutions, and the environment in order to analyze his/her own role in society and to develop a sense of personal identity

  C. The fundamental life processes, emphasizing the relationship of structure and function

  D. The relationship of organisms to their biological and physical environments in order to know the complex inter-relationships which exist among living things

  E. A working knowledge of the microscope and other tools found in the laboratory

  F. The modern theory of cellular structure and function

  G. The role that heredity plays as a vital part in determining an organism's characteristics

  H. The role of chromosomes and genes as the substance of heredity

  I. A familiarity with Mendel's laws of heredity and the significance of his contribution to genetics

  J. An introduction to problem solving genetics - human inheritance

  K. The ways that living things have changed through the ages and that further changes will occur; various theories advanced by biologists

  L. The ways that infectious diseases can be transmitted

  M. The ways that micro-organisms cause disease

  N. The methods of defense of the study against disease and the various types of immunities

O. Homeostases (steady state) where fine adjustments are made in order for the entire organism to stay in balance

P. A working knowledge of diffusion through a membrane and osmosis

Q. The differences among nonseed plants

R. The characteristics of angiosperms, monocots and dicots, herbaceous and woody plants, annuals, biennials, and perennials

S. A working knowledge of the earthworm's anatomy through dissection and the functions of the anatomical parts

T. The role of different parasites and their relationship to humans

U. An awareness of different kinds of arthropods and the characteristics of each kind with special attention to the crayfish

V. An acquaintance with the taxonomy of vertebrates, the complexity of structure, and the function from the lower to the higher forms of life

W. A working knowledge of the frog's anatomy through dissection and the functions of the anatomical parts

X. Ecology - populations, communities, and ecosystems - habitats and food chains

Y. The interactions of the biotic community with the physical environment; the interactions of the biotic community within itself and passive and adaptive behaviors

II. Content Outline

A. Value of science
   1. What is science
   2. Problems of a scientist (limitations)

B. Measuring
   1. Measuring in metric
      a. Relative relationships of metric to English units
      b. Measurement of objects in centimeters and millimeters with a meter stick
      c. Measurement of liquids using graduated beakers and cylinders
      d. Measurement of solids using scales and gram masses
      e. Measuring temperature with a Celsius thermometer, comparison of Celsius to Fahrenheit
   2. Fundamental understanding of mathematics
      a. Proper placement of decimals when utilizing addition, subtraction, multiplication, and division, changing fractions to decimals

b. Averaging with mean, median, and/or mode, and knowing when to utilize each kind of average
c. Making and interpreting graphs, demonstrating relationships using a constant and a variable
3. Research method
a. Define a problem
b. Collect information on the problem
c. Form a hypothesis (a working explanation or trial answer)
d. Experiment to test the hypothesis utilizing a single variable (experimental factor) and a control
e. Observe and record data from the experiment
f. Draw (formulate) conclusions
4. Pure science compared to applied science
5. A working knowledge with the compound microscope

C. The cell and its environment
1. The cell theory
a. The cell is the unit of structure and function of all living things
b. Cells come from other cells by cell reproduction
2. The processes of a cell
a. Nutrition
b. Digestion
c. Absorption
d. Biosynthesis
e. Respiration
f. Excretion
g. Secretion
h. Response
i. Reproduction
3. Cell structures and functions
a. Microstructures
b. Ultra-microstructures
4. Different levels of structures (cells, tissues, organs, organ systems)
5. Homeostasis - the steady state where fine adjustments are made in order for the entire organism to stay in balance
6. A working knowledge of diffusion through a selectively permeable membrane
a. The cell membrane and homeostasis as determined by the size of particles, water solubility, absorption affects, and porosity
b. Osmosis, turgor pressure, plasmolysis

D. Heredity
1. Mendel's hypotheses
a. Inherited traits are controlled by factors (genes) which occur in pairs
b. Dominance and recessiveness - one factor (gene) in a pair may mask the other or prevent it from having effect
c. Segregation - a pair of factors (genes) is segregated (separated) in forming

2. Independent assortment - when the gene pairs on a given pair of chromosomes is separated, they are distributed to gametes completely independently of the way other gene pairs on other chromosomes are distributed
3. Genetic terminology
4. Punnett squares and probability
5. Monohybrid and dihybrid crosses
6. Complete dominance
7. Incomplete dominance
8. Sex linkage
9. Nondisjunction and genetic disorders
10. Gene linkage and crossing over
11. Causative agents of mutations
12. Polyploidy
13. Genes in human populations
14. A working knowledge of blood typing

E. Organic variation
   1. Theories on the origin of the earth, the atmosphere, and the origin of life itself
   2. Evidence
      a. Fossils in sedimentary rock
      b. Oparin's hypothesis
      c. Homologous organs
      d. Gene mutations
      e. Adaptive radiation
      f. Convergent evolution
      g. Speciation
      h. Isolation by physical barriers
      i. Migration
      j. Industrial melanism
      k. Vestigial organs
   3. Lamarck's theory of evolution
   4. Darwin's theory of natural selection
      a. All organisms produce more offspring than can actually survive
      b. Every organism faces a constant struggle to survive
      c. The individuals of a given species vary
      d. The individuals that are best adapted to the environment survive
      e. The organisms that survive pass their traits on to offspring
   5. DeVries theory of mutation

F. Infectious disease
   1. Koch's postulates
      a. Isolate the organism suspected of causing the disease
      b. Grow the organism in laboratory cultures
      c. Inoculate a healthy animal with the cultured organism and see if the animal contracts the disease
      d. If the animal contracts the disease, examine the animal and reisolate the organisms that caused the disease

2. Pathogenic organisms enter the body in different ways
    a. Contaminated food and water: typhoid fever, cholera, dysentery
    b. Contaminated air to nose, throat, lungs: colds, influenza, measles, mumps, whooping cough, diptheria, scarlet fever, tuberculosis, pneumonia, meningitis
    c. Contact on the skin and mucous membranes: chickenpox, virus, smallpox virus, syphilis, gonorrhea
    d. Wound infections - tetanus bacteria
    e. Human immune carriers: typhoid fever, scarlet fever, diphtheria, polio
    f. Arthropod carriers: houseflies, cockroaches, typhus fever (human body louse), bubonic plague (rat flies), spotted fever (tick), African Sleeping sickness (tsetse fly), malaria parasite (Anopheles mosquito), yellow fever virus (Aedes mosquito)
3. Different ways that organisms may damage the body
    a. Exotoxins - bacterial release of poisonous protein substance
    b. Preformed toxins (food poisoning) - bacterial exotoxins formed in foods
    c. Endotoxins - poison inside of the bacteria that is released when the bacteria dies and breaks down
4. Defenses against disease
    a. Structural
    b. Cellular
    c. Antibody
    d. Chemical
    e. Immunity
    f. Chemotherapy
    g. Antibiotics

G. The seed plants
  1. The advantages of the seed plant compared to the nonseed plant
  2. Gymnosperms compared to angiosperms
  3. The angiosperms - flowering plants
      a. Monocot compared to dicot
      b. Woody compared to herbaceous plants
      c. Annuals, biennials, and perennials

H. The worms
  1. Phylum Platyhelminthes
      a. Planaria - free living
      b. Flukes - a parasite that lives part of its life cycle in a snail and part in another host, such as in a sheep or a fish
      c. Tapeworms - a parasite mostly associated with improperly cooked pork and/or fish
  2 Phylum Nematoda
      a. Ascaris - a parasite found in one-third of the human population of the world, most commonly associated with improperly cooked pork and horse meat
      b. Hookworm - a parasite that bores through the skin of the feet, most commonly associated in warmer areas such as the southern states and careless sewage disposals

        c. Trichinella - a very dangerous parasite affecting the muscles and commonly associated with the muscles of pigs, dogs, cats, and rats
        d. Pinworm - parasitic
        e. Vinegar eel - harmless
    3. Phylum Annelida
        a. Leech - an external parasite
        b. Earthworm - to be studied intensively and dissected

I. The arthropods
    1. Class Crustacea
        a. The crayfish is to be studied intensely as representative of the Arthropods
        b. Has two body divisions (cephalothorax and abdomen), five pairs of legs and gills
    2. Class Chiopoda - centipede
    3. Class Diplopoda - millipede
    4. Class Arachnida: spider, mite, tick, and scorpion
    5. Class insects

J. Introduction to the vertebrates
    1. Characteristics of Chordates
        a. Notochord
        b. Tubular nerve cord
        c. Paired gill slits
    2. Characteristics of vertebrates
        a. A vertebral column or spine which is composed of cartilage or vertebrae. This backbone, along with the skull, forms the axial skeleton
        b. An anterior pectoral girdle and a posterior pelvic girdle are suspended from the spinal column and not found in all vertebrates
        c. Limbs (never more than two pairs) are attached to the pelvic and pectoral girdles to form the appendicular skeleton
    3. Behavior
        a. Innate (instinct) for self and species preservation
        b. Learned as with a conditioned response (reaction) and intelligent behavior

K. The fishes
    1. The jawless fish - sea lamprey
        a. Found in the Great Lakes
        b. Parasitses mostly lake trout and whitefish and pike
    2. The cartilage fishes - sharks, rays, and skates
    3. The bony fishes - in some form, live in practically every water environment

L. The amphibians
    1. Toads
    2. Salamanders
    3. Frogs
        a. The frog will be studied intensely and dissected in the laboratory as the representative animal for the vertebrates
        b. Behavior includes hibernation and an estivation

M. The reptiles
  1. Dinosaurs
  2. The Sphenodon (tuatara) - holdover from the past
  3. Snakes
    a. Most snakes are not poisonous and are beneficial to man
    b. Poisonous snakes in the United States include the rattlesnake, the water moccasin (cottonmouth), and the copperhead as representative of the pit vipers. The coral snake and the oceanic sea snake are representative of the cobras
  4. Lizards
    a. Iguanas - thought to be the most primitive lizard
    b. Gila monsters and beaded lizards - the only poisonous lizards
    c. Komodo dragon - largest lizard in the world
  5. Crocodiles, alligators, caimans, and gavials
  6. Turtles
    a. Tortoise - live on land
    b. Terrapins - live in fresh water
    c. True turtles - live in salt water

N. The mammals
  1. The characteristics of mammals
    a. Body covered with hair
    b. Viviporous - young nourished during development in the uterus of the mother
    c. Young nourished with milk secreted by mammary glands
    d. Lung breathing throughout life
    e. A breathing muscle (diaphragm)
    f. Four chambered heart with left aortic arch only
    g. Warm blooded
    h. Seven cervical (neck) vertebrae in most species
    i. Two pairs of limbs in most species
    j. Cerebrum and cerebellum of the brain are highly developed
  2. The orders of mammals
    a. Monotemes (egg laying) - platypus, spiny anteater
    b. Marsupials (pouched mothers): kangaroo, oppossum, koala bear, wallabies, Tasmanian devil (flesheater resembling the raccoon), Tasmanian wolf (flesheater resembling the wild hog)
    c. Insect eating: shrews and moles
    d. Flying: bats and vampires
    e. Gnawing - rodents
    f. Rodentlike: rabbit and hare
    g. Toothless: tree sloth and anteater
    h. Aquatic: whales, dolphins, porpoises, manatee
    i. Trunk (nosed) - elephants
    j. Hoofed: goats, horses, cows, pigs, etc.
    k. Erect: monkeys, apes, people

O. Ecology
  1. All organisms depend on their surroundings for carrying on the activities of life

- a. Population - a group of organisms of the same species
- b. Community - two or more populations living together
- c. Environment - includes water, wind, air pressure, etc.
- d. Ecosytem - a community and its environment

2. Density - dependent factors
    - a. Reproductive and death rates
    - b. Disease and parasitism
    - c. Predation
3. Density - independent factors
    - a. Affect the population no matter what the density is
    - b. Changes in weather, temperature, humidity, daily and seasonal light, and available energy

- P. The habitat
    1. The physical environment
    2. Food chains and food webs
    3. Ecological pyramids
    4. Nutritional relationships
        - a. Bulk feeders
        - b. Saphrophytes
        - c. Symbiosis: parasitism, mutualism, commensalism
    5. Passive protection
        - a. Protective coloration
        - b. Countershading
        - c. Protective resemblance
        - d. Mimicry
    6. Adaptive behavior

III. Concepts to be Taught

- A. Diversity
    1. Differences are exhibited among different species; and differences are exhibited among organisms of the same species
    2. Identification of differences in the human result from genetic and environmental conditions
    3. Sex linkage demonstrates that more differences from the normal can occur in males than in females
    4. Living things are not distributed uniformly over the surface of the earth but are found in definite zones and local regions where conditions are favorable to their survival
    5. The biological functions of color are to conceal, to disguise, or to advertise
    6. Monocots have different structural arrangements than dicots
    7. Flowers are of many types: staminate, pistillate or both
    8. Certain organisms are classified in such a way that they do not fit the classifications of either plants or animals
    9. Different vertebrates inhabit different areas of the environment land, air, and water
    10. The chordates include a great variety of organisms: sharks, perch, frogs, cobras, bluebirds, and humans
    11. Amphibians live part of their life in an aquatic environment and the other part on land

B. Grouping
1. Common properties exist in the various units of the metric system
2. An interdependence of living organisms exists in the balance of nature
3. Numbers can be grouped to determine mean, median, and mode to identify common properties
4. Cells are basically similar
5. All cells come from pre-existing cells
6. The energy that supplied all life on the earth comes ultimately from sunlight through the process of photo-synthesis
7. All plants and animals are engaged in a constant struggle for energy
8. A population is a group of organisms of the same species which occupies a given area
9. Protozoans are single celled organisms that conduct all the basic processes of life
10. The flatworms, roundworms, and segmented worms are the first organisms to have organs
11. The grasshopper displays the basic characteristics of most arthropods in having an exoskeleton of cartilage, a segmented body, and jointed appendages
12. All chordates possess a notochord; in vertebrates this notochord evolves into a backbone
13. There is a unique relationship of structure and function shown in such vertebrates as fish, frogs, snakes, birds, and humans
14. The fishes are the most numerous of all the vertebrates
15. Every organism comes into the world with a certain inherited endowment of congenital behavior
16. Many invertebrates cause disease in humans

C. Hierarchial order determination
1. Organisms can be placed in a super and subordination since there exists developed structures in some organisms, partially developed structures in other organisms, and nonexistant structures in still other organisms
2. Classification provides a way to categorize organisms according to their structure, locomotion, or biochemcial properties
3. Cells are organized into tissues, tissues into organs, and organs into organ-systems
4. From lower forms of life to higher forms, there exists an increasing complexity of structure; and this is accomplished by a progressive increase in the division of labor
5. All cells require raw materials to provide energy and/or to build new protoplasm
6. The smallest unit of living material capable of existing independently and of maintaining itself is a unit called a cell
7. All gradations of association occur in intimate associations between organisms, from those that are mutually beneficial to the individuals concerned to those in which one member secures all of the advantages at the expense of the other
8. People are the supreme vertebrate because of their highly developed nervous system

D. Cause and effect relationships
   1. There are causative agents that can result in a mutation
   2. Throughout the life of every organism, there is a building up and a tearing down
   3. Unsatisfactory sanitary conditions can result in the spread of a disease
   4. Pollution can radically change the environment causing a change of the kind of organisms that can be supported by that environment
   5. Living organisms affect the environment and are in turn affected by the environment
   6. Living organisms require food and oxygen for energy and growth and must eliminate carbon dioxide, water, and metabolic waste
   7. Decomposition of carbon compounds of organisms provide a replenishment of carbon in the atmosphere in the form of carbon dioxide; this carbon is continually being subjected to a series of cyclic changes from living to nonliving substances
   8. The organisms most likely to survive are those that are structurally and physiologically best fitted to their environment
   9. Pollination is the first step in the formation of seeds and is often accomplished by insects, wind, water, and/or birds
   10. Plants respond to stimuli, but their responses are very slow
   11. Organisms are slowly changing, both structurally and functionally, in response to changes in their physical environment
   12. The organisms most likely to survive and reproduce are those that are structurally and physiologically best fitted to their environment
   13. New kinds of organisms have arisen through mutation
   14. Heredity supplies the native capacities of an organism; environment determines, to a large extent, how fully these capacities will be developed

E. Hypothesizing
   1. Inferences can be made from rough ratios to formulate rounded ratios
   2. All plants and animals are engaged in a constant struggle for energy
   3. The surface of the earth and the atmosphere surrounding the earth are undergoing changes; therefore, organisms must migrate, hibernate, estivate, build artificial shelters and become adapted or die
   4. When the balance of nature is disturbed, disastrous results often follow

F. Verification
   1. Logical principles and/or factual knowledge can be used to determine necessary and sufficient conditions to support a prediction or hypothesis
   2. Characteristics of a population are the functions of the whole group and not a single individual. These include population density, birth rate, death rate, rate of migration, rate of immigration, rate of emigration, age, and distribution
   3. Correct utilization of questionnaires and random supplies support predicitons
   4. Laboratory experiments support hypotheses

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

BASIC SCIENCE 408

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Basic Science 408
GRADE TEN

This elective course offers one credit toward graduation. Upon successful completion of the course, the student will demonstrate an understanding of the following:

I. Instructional Objectives

A. A greater exchange of ideas and feelings between themselves and the teacher by attempting to develop an awareness of self and of others, as well as fostering improved communication and listening skills

B. The role of the individual in society and the interaction of the individual with traditions, institutions, and the environment in order to analyze his/her own role in society and to develop a sense of personal identity

C. The basic nature of people stressing awareness of our motivations and behaviors, as well as the consequences of certain behavior

D. The interdependence of living things and the balance of nature

E. The evidence of people's intrusion into the environment; and their detrimental effect on the natural environment

F. The environmental influence of plant and animal life including the human

G. The diversity of plants and animals

H. The observations and experiments of scientist

I. The fundamentals of mathematics including metrics

J. The maintainment of the healthy and normally funtioning body

K. The genetic characteristics that exist; and the influences of the environment

L. The effects of weather on the human

M. The effects of pollution, overconsumption, and overpopulation

N. The advantages and importance of space travel

O. The appreciation of science and scientific methods

P. The verification of hypotheses through the data collected from experimentation

Basic Science 408
GRADE TEN

II. Content Outline

A. Value of science
  1. What is science
  2. Methods of a scientist
  3. Problems of a scientist

B. Measuring
  1. Measuring in metric
    a. Relative relationships of metric to English units
    b. Measurement of objects in centimeters and millimeters with a meterstick
    c. Measurement of liquids using graduated beakers and cylinders
    d. Measurement of solids using scales and gram masses
  2. Fundamental understanding of mathematics
    a. Proper placement of decimals when utilizing addition, subtraction, multiplication, and division; changing fractions to decimals
    b. Averaging with mean, median, and/or mode; knowing when to utilize each kind of average
    c. Making and interpreting graphs; demonstrating relationships using a constant and a variable
  3. Reading scales
    a. Measurement of angles with a protractor
    b. Applying measurement of angles to the use of rain guages, air pistons, and electrical meters
    c. Measuring temperature with a Celsius thermometer; comparison of Celsius to Fahrenheit

C. Investigating variation
  1. Diversity
    a. Comparison of number of students who are right and left handed; right eyed or left eyed; and learning how to make and interpret tallies
    b. Operationally define terms
    c. Judging of lines using optical illusions
  2. Differentiation of "either/or" and "continuous variation"
  3. Mathematical applications
    a. Patterns by grouping
    b. Utilization of historgrams
    c. Determining mean, median, and mode and determining when to use each
    d. Utilizing contingency tables
  4. Identification of fingerprints
  5. Sampling populations
    a. Collecting data, graphing, and interpreting
    b. Plotting a curve and application of "usual", "not very typical", and "most typical"
    c. Making and ensuring the acquirement of a random sample

D. Well being
  1. Activity
    a. Determining types of activities
    b. Measuring in calories
    c. Disadvantages of being over weight and under exercised
  2. Effects of smoking
    a. Diseases such as cancer and emphysema
    b. Fingertip temperature
  3. Chemicals in the body
    a. Drugs
    b. Alcohol
    c. Coffee, tea, and colas
    d. Placebos
  4. Learning about parts of the body
    a. Cells
    b. Heart

E. Why your're you
  1. Determining genetic characteristics
    a. Pure strain mated with a pure strain
    b. Pure strain mated with a hybrid strain
    c. Hybrid strain mated with a hybrid strain
    d. Making monohybrid crosses
    e. Making dihybrid crosses
  2. Determining probabilities of first and second generation organisms
    a. Formulating rough ratios
    b. Formulating rounded ratios
    c. Calculating mathematically correct ratios
  3. Becoming familiar with genetic characteristics
    a. Taster (PTC)
    b. Attached ear lobes
    c. Tongue roller
    d. Hitchhiker's thumb
    e. Dimples
    f. Widow's peak
    g. Gap between teeth
  4. Causes and resulting effects of mutations
  5. Incomplete dominance (blending)
  6. Sex linkage
    a. X chromosome
    b. Baldness
    c. Hemophilia
    d. Making geneological charts
  7. Influences of environmental factors such as sunlight, exercise, and diet
    a. Tanning
    b. Freckles
    c. Intelligence
    d. Hair color
    e. Weight

      f. Height
      g. Size of muscles
      h. Handedness

F. Winds and weather
   1. Effects of warm and cool air
   2. Watching the weather and knowing about the weather
      a. Date and time of day
      b. Temperature
      c. Wind direction and wind speed (mph)
      d. Cloud type and cloud cover
      e. Precipitation (inches)
      f. Barometric pressure (inches)
      g. Relative humidity
      h. Dew point (degrees Celsius)
   3. Moving weather
   4. Weather prediction and forecasting

G. Environmental science
   1. Living organisms affect each other
      a. History of the Black Death
      b. Organisms that cause disease
      c. Pollution of animal wastes
      d. Some organisms benefit from other organisms
   2. Living organisms affect the environment and are, in turn, affected by the environment
      a. Air pollution
      b. Water pollution
      c. Noise pollution
      d. Detergents
      e. Biodegradable wastes
      f. Depletion of oxygen on fish
      g. Increase of water temperature on fish
      h. Increase of nutrients in the water and the effects on water organisms
   3. Comparison of air pollutants of a gasoline engine with a diesel engine
   4. Problems to be solved
      a. Overconsumption of material goods
      b. Overpopulation
      c. Adapting to new environments
      d. Travel in space to other planets or space stations

H. In orbit
   1. Characteristics of the sun
      a. Composition (elements and spectrum)
      b. Emission of energy per minute
      c. Determination of the distance to the sun
      d. Size determination
      e. Motion description

2. Work is relative to energy
3. The moon's measurements
    a. Calculation of the distance around the moon's orbit
    b. Measurement of time it takes the moon to move from point A to point B
    c. Determination of the moon's diameter
4. Make scale drawings
5. Learn how to use a telescope and a sundial
6. A study of the history of the calendar

I. What's up
1. Description of rockets
    a. Types and sizes
    b. How much fuel is needed and what kinds best produce the needed energy for lift off, flight, and splash down
2. Satellite orbits
    a. Vertical rise
    b. Tilt
    c. Coasting path
    d. Orbit injection
    e. Orbit path
3. Free return to and from the earth to the moon
    a. Lift off and insertion in parking orbit
    b. Parking orbit around the earth
    c. Insertion in free return path to the moon
    d. Free return to the moon
    e. Capture by the moon's gravity and half orbit around the moon
    f. Leave the moon's gravity and head back to the earth on free return path
    g. Capture by the earth's gravity and half orbit around the earth
4. Geographic features
    a. Craters
    b. Peaks
    c. Flows (magma)
5. What do you need to know to spend a day on the moon

III. Concepts to be Taught

A. Diversity
1. Differences are exhibited among different species; and differences are exhibited among organisms of the same species
2. Identification of differences in the human result from genetic and environmental conditions
3. There are differences which cannot be changed such as fingerprints
4. Sex linkage demonstrates that more differences from the normal can occur in males than in females
5. Living things are not distributed uniformly over the surface of the earth but are found in definite zones and local regions where conditions are favorable to their survival

Basic Science 408
GRADE TEN

B. Grouping
   1. Common properties exist in the various units of the metric system
   2. An interdependence of living organisms exists in a balance of nature
   3. Numbers can be grouped to determine mean, median, and mode to identify common properties
   4. Living organisms affect the environment and are, in turn, affected by the environment

C. Hierarchial order determination
   1. Organisms can be placed in a super and subordination since there exists developed structures in some organisms and nonexistent structures in still other organisms
   2. Classification provides a way to categorize objects according to its shape, color, size, etc.
   3. Cells are organized into tissues, tissues into organs, and organs into systems
   4. From lower forms of life to higher forms, there exists an increasing complexity of structure; this is accompanied by a progressive increase in the division of labor

D. Cause and effect relationships
   1. There are causative agents that can result in a mutation
   2. Throughout the life of every organism there is a building up and a tearing down
   3. Unsatisfactory sanitary conditions can result in the spread of desease
   4. Pollution can radically change the environment causing a change of the kind of organisms that can be supported by that environment

E. Hypothesizing
   1. Inferences can be made from rough ratios to formulate rounded ratios
   2. All plants and animals are engaged in a constant struggle for energy
   3. The surface of the earth and the atmosphere surrounding the earth are undergoing changes; therefore, organisms must migrate, hibernate, estivate, build artificial shelters, and become adapted or die
   4. When the balance of nature is disturbed, disastrous results often follow

F. Verification
   1. Logical principles and/or factual knowledge can be used to determine necessary and sufficient conditions to support a prediction or hypothesis
   2. Characteristics of a population are the functions of the whole group and not a single individual. These include population density, birth rate, death rate, rate of migration, rate of immigration, age, and distribution
   3. Correct utilization of questionnaires and random samples support predictions
   4. Laboratory experiments support hypotheses

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

CHEMISTRY 402/414

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Chemistry 402
Honors
GRADE TEN
Average and Above 414
GRADE ELEVEN

Chemistry 402/414 are elective courses recommended for all students who plan to attend college and who need a good science (chemistry) background for their major field or career choice. The courses are designed to provide the needed factual background, problem solving experiences, and laboratory skills required to successfully complete any introductory college chemistry course. These courses offer one credit toward graduation.

Students enrolled in these courses should have completed two years of high school mathematics and be presently enrolled in a third year of mathematics.

Emphasis is placed on the use of both concrete and formal operational skills involving the use of chemical concepts and the solving of mathematically based chemical problems. Another emphasis is the application of chemical knowledge to "everyday life" and to possible solutions of current problems such as energy and pollution.

I. Instructional Objectives

A. To develop in students a more complete understanding of the physical world around them through a study of matter and its properties as determined by molecular structure

B. To present students the current and practical facts concerning chemicals in their everyday environment including home, city, nation and universe, and to encourage them to take an active, knowledge-based, role in the solving of current problems related to materials and their uses

C. To emphasize the "universality" of chemical concepts and to increase student confidence in their application through a repetitive sequence of difficult ideas in increasing depth and with varying emphasis

D. To foster independent thinking by having students use the scientific method, proceeding from the known to the unknown, in both text and laboratory exercises

E. To help students progress from the "concrete" operational stage where they are able to deal only with the reality presented to the "formal" operational stage where they can grasp the theories and their implications
   1. The extensive use of concrete laboratory experiments, demonstrations and physical models
   2. A systematic approach to problem solving using sets of increasing difficulty in each concept unit

3. The use of "report" writing as an exercise in thought processes and concept understanding

F. To improve student reading skills and help them develop a vocabulary related to science in general and chemistry in particular, thus increasing their ability to use the terms and understand language as it relates to major concepts and problems

G. To increase student understanding and appreciation of the necessity for SAFE handling of all materials in all situations (home, work, and school) through emphasis on safety precautions in all experimental work and discussions of current issues regarding the safe handling of chemicals

H. To stimulate student creativity through encouragement of individual work on projects or papers in addition to class required work

II. Content Outline

A. Matter

B. Energy

C. Physical and chemical properties

D. Elements, compounds, and mixtures

E. Physical and chemical changes

F. Atomic structure

G. Electron arrangements

H. Periodic law

I. Chemical bonding

J. Formula and equation writing

K. Nomenclature

L. Mole concept

M. Stoichiometry

N. Kinetic theory

O. Properties of solids, liquids, and gases

P. Le Chatelier's principle and equilibrium

Q. Gas laws

R. Phase changes

S. Solutions and solubility

T. Ionization

U. Acids, bases, and salts

V. pH

W. Reaction rates and reaction kinetics

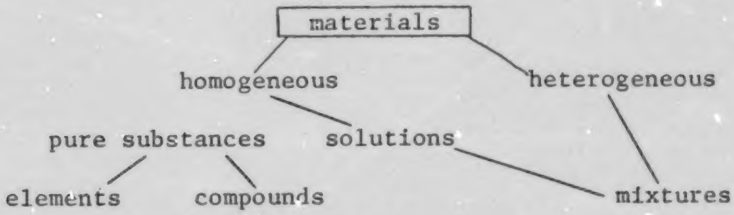
X. Measurement - scale and order of magnitude

Y. Major skills involved in laboratory work
    1. Observe
    2. Measure - mass, volume
    3. Measure - melting or boiling temperature
    4. Measure pH
    5. Characterize, compare, identify
    6. Decant or filter
    7. Titrate
    8. Pipet
    9. Mix or dissolve
    10. Extract or separate
    11. Precipitate
    12. Record
    13. Graph
    14. Calculate
    15. Analyze or interpret data
    16. Build models

III. Concepts to be Taught

A. Nature, chemistry and you
    1. The definition of chemistry, its relationship to everyday life and career choices
    2. Matter and energy
        a. Matter - definition, phase, and properties
        b. Energy - definition, forms
    3. Measurement and the metric system
        a. Units - definition, relationships, and conversions
        b. Uncertainty in measurements - accuracy, precision, and significant digits
        c. Scientific notation
    4. Problem-solving introduction of the factor-label method as applied to metric conversions
    5. Density - an experience in using measurements to arrive at a concept
    6. Scientific method - including a discussion of experimental work leading from hypotheses to theories and ultimately to laws

B. Matter and its changes
   1. Classification and phases
      a. Homogeneous and heterogeneous
      b. Elements, mixtures, and compounds (see outline below)



   2. Properties and changes
      a. Physical
      b. Chemical
   3. Energy and changes
      a. Forms
      b. Reaction tendencies

C. Chemical shorthand
   1. Symbols of elements
   2. Formulas and nomenclature of compounds (empirical and molecular)
   3. Chemical reactions - representing, balancing, and classifying
   4. Energy and chemical change

D. The mole
   1. Particular masses and Avogadro's number
   2. Calculations on compounds
      a. Percentage composition
      b. Empirical and molecular formulas
   3. Calculations on reactions, mass-mass relationships
   4. Energy changes
      a. Heat measurement and calculations
      b. Heat of chemical reaction (H) heat of formation (H_f) and the calculations related

E. Atomic structure
   1. Atomic theory - historical perspective
   2. Laws of chemical composition - definite and multiple proportions
   3. Atomic particles, isotopes and masses
   4. Size and shape of atom and its parts
   5. Quantum theory

F. Electrons and clouds
   1. Development of the wave - mechanical view of the hydrogen atom
   2. Description of atom from Schrodinger equation
   3. Orbital theory applied to all atoms - use of orbital notation and diagrams to represent electron distribution in atoms
   4. Electron dot representation of outer electrons

Chemistry 402/414
GRADES TEN AND ELEVEN

G. The periodic table
   1. Historical development
   2. Survey of modern table including major parts and classification of elements
   3. Representative electropositive (Na^+) and electronegative (Cl^-) elements
   4. Predictions based on table and outer electrons

H. The process of bonding
   1. Ionization energies and electron affinities (electronegativity)
   2. Bond types - related to electronegativity
      a. Ionic bonding and radii
      b. Covalent bonding and radii
      c. Van der Waals radii
      d. Metallic bond and properties of metals

I. The results of bonding
   1. Electron pair repulsion and molecular shapes
   2. Hybrid orbitals and their occurrence in carbon compounds
   3. Resonance
   4. Molecular orbital theory

J. Structure and properties of molecules
   1. Variations in shape - isomerism, optical activity, and polarity
   2. Complexions - bonding and isomerism
   3. Chromatography - column, surface, and gas

K. Kinetic theory
   1. Particle motion and methods of measurement
      a. Pressure
      b. Temperature
   2. States of matter (including plasma)

L. Solids
   1. Crystal structure
   2. Unit cells and closest packing
   3. Applications to different types of substances - metallic, nonmetallic, network, and macromolecular

M. Liquids
   1. Liquid-vapor equilibrium and pressure measurements
   2. Phase changes (liquid-vapor, liquid-solid) and phase diagrams
   3. Properties of liquids
      a. Hydrogen bonding
      b. Surface tension and capillary rise

N. Gases
   Gas laws
      a. Boyle's law and its application (pressure-volume)
      b. Charles's law and its application (pressure-temperature)
      c. Dalton's law of partial pressures

        d. Graham's law (diffusion)
        e. Real vs. "ideal" gases

O. Gases and the mole
    1. Avogadro's principle and molar volume
    2. Ideal gas equation
    3. Molecular mass from gas measurements
    4. Gas reaction calculations - including limiting reactant concept
        a. Mass-volume
        b. Volume-volume
        c. Nonstandard conditions

P. Energy and disorder
    1. Spontaneous changes - entropy, enthalpy, and free energy
    2. Calculations on free energy
    3. Energy and work

Q. Solutions
    1. Dissolving process including combinations, equilibrium, rates, and heats
    2. Concentration of solutions
    3. Colligative properties
    4. Colloids and their properties

R. Acids, bases, and salts
    1. Acid-base theories - Arrhenius, Bronsted-Lowry, and Lewis
    2. Nomenclature
    3. Acidic and basic anhydrides
    4. Acid-base equilibria
        a. Strengths of acids and bases
        b. Ionization of acids and bases and ion constant (K_a)
        c. Common ion effect
    5. Salts and water
        a. Solubility product constant
        b. Ionization of water and constant (K_w)
        c. pH scale and calculations
        d. Indicators and titration
        e. Hydrolysis and buffers

S. Oxidation - reduction
    1. Electron transfer and definitions
    2. Oxidation numbers and rules for assigning them
    3. Oxidation-reduction reactions and the balancing of them

T. Electrochemistry
    1. Conductivity, electrode potential difference, and electrode reactions
    2. Electrochemical cells and energy
        a. Effect of conditions
        b. Energy relationships
        c. Calculations using standard potentials

U. Reaction rate and chemical equilibrium
   1. Rates of reaction and the factors affecting them
   2. Reaction mechanisms and the collision theory
   3. Chemical equilibrium and the equilibrium constant (K_{eq})
   4. Free energy and equilibrium

V. Nuclear chemistry
   1. Elementary particles and nuclear structure
   2. Nuclear stability and "half-life" calculations
   3. Nuclear reactions
      a. Fusion - state of the art
      b. Fission - nuclear power and the current controversy

W. Organic chemistry
   1. Hydrocarbons - occurrence, classes, structure, nomenclature, and properties
   2. Deravitives of hydrocarbons - halogen, oxygen, nitrogen compound
   3. Organic reactions - substitution, addition, elimination, and esterification
   4. Oil and the energy crisis

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

CHEMISTRY 411

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Chemistry 411
Advanced Placement
GRADE ELEVEN

Advanced placement chemistry represents a general chemistry course on the college level. Successful completion of the course enables the student to take the AP exam in May and to receive college credit and/or placement.

I. Instructional Objectives

A. The student should develop an understanding about how the principles of chemistry are experimentally established and applied in predictions of reaction feasibility

B. The student should develop an understanding of systematic nomenclature and the experimental meaning of such terms as complexion, equilibrium shift, etc.

C. The student should gain experience with quantitative aspects of experiments by using such chemical techniques as colorimetry, potentiometric measurements and filtration among others

D. The student should be able to work a variety of chemistry problems correctly using significant figures, logarthmic and exponential equations, and understand the precision of measured values

II. Content Outline

A. Atomic theory and atomic structure
   1. Evidence for the atomic theory
   2. Atomic weights, determination by chemical and physical means
   3. Atomic number and mass number, isotopes and mass spectroscopy
   4. Electron energy levels: atomic spectra, quantum numbers, atomic orbitals
   5. Periodic relationships including, for example, atomic radii ionization energies, electron affinities, electronegativities

B. Chemical bonding
   1. Binding forces
      a. Types: molecular, ionic, metallic, macromolecular (or network), van der Waals, hydrogen bonding
      b. Relationships to structure and to properties
      c. Polarity of bonds
   2. Geometry of molecules, ions, and coordination complexes, structural isomerism, dipole moments of molecules, relation of properties to structure
   3. Molecular models
      a. Valence bond theory: hybridization of orbitals, resonance, sigma, and pi bonds
      b. Other models, e.g., molecular orbital

Chemistry 411
GRADE ELEVEN

C. Nuclear chemistry: radioactivity and chemical applications

D. Gases
   1. Laws of ideal gases, equation of state for an ideal gas
   2. Knietic-molecular theory
      a. Interpretation of ideal gas laws on the basis of this theory
      b. The mole concept - Avogadro's number
      c. Dependence of kinetic energy of molecules on temperature, Boltzmann distribution
      d. Deviations from ideal gas laws

E. Liquids and solids
   1. Liquids and solids from the kinetic-molecular viewpoint
   2. Phase diagrams of one-component systems
   3. Changes of state, critical phenomena

F. Solutions
   1. Types of solutions and factors affecting solubility
   2. Methods of expressing concentration
   3. Phase diagrams of two-component systems
   4. Raoult's law - determination of molecular weights
   5. Effect of interionic attraction on colligative properties and solubility

G. Colloidal and macromolecular dispersions: classifications, industrial, and ecological applications

H. Reaction types
   1. Formation and cleavage of covalent bonds
      a. Acid-base reactions, concepts of Arrhenius, Bronsted-Lowry, and Lewis amphoterism
      b. Reactions involving coordination complexes, amphoterism
   2. Precipitation reactions
   3. Oxidation-reduction reactions
      a. Oxidation number
      b. The role of the electron in oxidation-reduction
      c. Electrochemistry, electrolytic cells, standard half-cell potentials: prediction of the direction of redox reactions, effect of concentration changes

I. Equations
   1. Ionic and molecular species present in chemical systems - net systems
   2. Stoichiometry - weight and volume relations with emphasis on the mole concept
   3. Balancing of equations including those for redox reactions

J. Equilibrium
   1. Concept of dynamic equilibrium, physical and chemical, LeChatelier's principle, equilibrium constants, activity
   2. Quantitative treatment
      a. Equilibrium constants for gaseous reactions in terms of both molar concentrations and partial pressures

- b. Equilibrium constants for reactions in solution
    - 1) Constants for acids and bases - pK, pH
    - 2) Solubility product constants and their application to precipitation and the solution of precipitates
    - 3) Constants for complex ions
    - 4) Common ion effect - buffers

K. Kinetics

1. Concept of rate of reaction
2. Order of reaction and rate constant, their determination from experimental data
3. Effect of temperature change on rates
4. Energy of activation, the role of catalysts
5. The rate-determining step in deducing reaction mechanisms

L. Thermodynamics

1. State functions
2. First law: heat of formation, heat of reaction, change in enthalpy, Hess's law, heat capacity, heat of vaporization and fusion
3. Second law: free energy of formation, free energy reaction, dependence of change in free energy on enthalpy, and entropy changes
4. Relationship of change in free energy to equilibrium constants and electrode potentials

M. Descripitive chemistry

1. Relationships in the periodic table, horizontal, vertical, and diagonal
2. Important elements and typical periodic table families: oxygen, hydrogen, noble gases, halogens, sulfur family, nitrogen family, carbon, silicon, boron, aluminum, alkaline-earth metals, alkali metals, transition metals
3. Physical and chemical properties of compounds of carbon

N. Chemical calculations

1. Percentage composition
2. Empirical and molecular formulas from experimental data
3. Molecular weights from gas density, freezing-point, and boiling-point measurements
4. Gas laws, including the ideal gas law, Dalton's law, and Graham's law
5. Stoichiometric relations using the concept of the mole - titration calculations
6. Mole fractions - molar and molal solutions, normality optional
7. Faraday's laws of electrolysis
8. Equilibrium constants and their applications including their use for simultaneous equilibria

10. Thermodynamic calculations
11. Kinetic calculations

Chemistry 411
GRADE ELEVEN

III. Concepts to be Taught

A. Structure of matter

1. The arrangements of electrons and nuclei in atoms, ions, and molecules form the theoretical basis of all chemistry
2. The atomic theory is supported by evidence such as electrical discharge through gases, atomic and molecular spectra, x-ray, diffraction by crystalline solids and radioactivity
3. The electronic structure of atoms or the characterization of an electron is indicated by its quantum number, sublevel, orbital and spin. It can also be described by its electron configuration
4. A balanced equation reflects the observed mass relationships between reactants and products and the conservation of matter
5. Strong chemical bonds and weak physical bonds are electrostatic in nature
6. Chemical bonds are classified according to the extent to which the electron distribution within atoms is changed when the atoms are attracted to one another
7. Physical bonds or intermolecular forces determine the properties of molecular substances, such as melting point, boiling point, vapor pressure, and heat of vaporization
8. The geometry of a molecule and the relative electro-negativities of its atoms determine whether it is polar or nonpolar
9. Radioactive decay follows the first order rate law and results in a new, more stable nucleus
10. Spontaneous nuclear reactions evolve large amounts of energy, mostly in the form of heat and can be accounted for quantitatively

B. States of matter

1. The physical behavior of gases is described by the ideal gas law, $PV = nRT$ and can be applied to gas mixtures, as well as pure gases
2. The kinetic theory states that at a given temperature, molecules of all gases have the same kinetic energy of translation. This makes possible the ability to derive equations for the average molecular velocity of a gas at a given temperature
3. The major distinction between gases and liquids and solids is the separation distance between molecules. In the gas state the molecules account for a negligible fraction of the total volume, while in the liquid and gas state, the molecules occupy from 50 - 70% of the total volume
4. In the condensed state intermolecular forces exert a strong influence on physical behavior, such as density, compressability, and expansibility
5. At any given temperature a liquid or solid has a characteristic vapor pressure which rises exponentially with temperature
6. The triple point is that temperature and pressure at which all three states of a substance are in equilibrium with each other
7. Complete miscibility of two substances occurs if they are in the same physical state and the closer a solid or a gas is to the liquid state the greater is its solubility

8. Solute solubility may change by changing the external temperature and pressure
9. The magnitude of the colligative properties of solutions depends primarily on the concentration of the solute particles

C. Reactions
1. Equilibrium constants for the reactions of weak acids with strong bases or weak bases with strong acids, one smaller than that for neutralization but are large enough to drive the reaction to completion
2. The indicator used to determine the concentration of an acid or base solution has Ka equal to the concentration of H^+ at the equivalence point
3. A solution containing a mixture of a weak acid and its conjugate base acts as a buffer which prevents a drastic change in pH when acid or base is added
4. The Arrhenius definition of acids and bases is: a species which in water, give H^+ or OH^- respectively. The Bronsted-Lowry definition - an acid is a proton donor and a base is a proton acceptor. The Lewis definition - an acid is an electron-pair acceptor and a base is an electron-pair donor
5. A precipitation reaction will occur when two electrolyte solutions are mixed if one of the products is insoluble. Solubility rules predict the spontaneity of precipitation reactions
6. Oxidation-reduction reactions involve a transfer of electrons from a reducing agent to an oxidizing agent
7. The sum of the oxidation numbers of all atoms in a species is equal to the charge of that species
8. From measurements on voltaic cells, it is possible to obtain standard potentials which are a measure of the tendency of species to be reduced or oxidized. Large positive values for the reduction potential imply a species is easily reduced. Large positive oxidation potentials imply a species is easily oxidized
9. The standard voltage, E^o, can be directly related to the standard free energy change and to the equilibrium constant for the reaction
10. The extent of a reaction for a system at equilibrium can be described by a ratio of molar concentrations equal to the equilibrium constant, Kc. Kc Depends on the particular substances in the reaction and the temperature
11. By comparison to Kc it can be determined whether a system is in a state of equilibrium or how a given change in conditions will affect a system that is at equilibrium
12. Reaction rates depend on the concentration of reactants and the temperature
13. Reaction mechanisms involve a series of steps and, in many cases, one step is considerably slower than the others and determines both the overall rate and the reaction order
14. Activiation energy, Ea, represents the minimum energy that must be available for a useful collision. Catalysts lower the Ea by finding a different reaction path with a lower energy barrier

15. The capacity of a reaction to produce work can be related to a fundamental property of substances known as free energy. The difference in free energy, ΔG, between products and reactants
16. Spontaneous reactions are ones for which the products have a lower free energy than the reactants. If the free energy of the products is greater than that of the reactants, work must be done to make the reaction go and the reaction is nonspontaneous
17. The enthalpy change, ΔH, is the amount of heat absorbed or evolved when a reaction is carried out at constant pressure. If the bonds of the product are stronger than those in the reactants ΔH will be negative and the reaction will be exothermic. Exothermic reactions will tend to be spontaneous
18. A positive value for the change in entropy, ΔS, of a reaction will contribute to a spontaneous reaction
19. The balance between ΔH and ΔS depends on the absolute temperature, T. At low temperature $T\Delta S$ will be small and the sign of ΔG will be that of ΔH
20. ΔH is independent of both temperature and pressure. ΔS is relatively independent of temperature but is strongly dependent on pressure. ΔG is dependent on temperature and pressure

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

PHYSICS 424

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Physics 424
Average and Above
GRADES ELEVEN AND/OR TWELVE

This elective course offers one credit toward graduation. Upon successful completion of the course, the student will demonstrate an understanding of the following:

I. Instructional Objectives

A. Understand the basic uniting principles of physical science which serve to give continuity to scientific endeavor

B. Have been exposed to a variety of laboratory experiences to discover, reinforce, and/or verify physical laws

C. Have been exposed to a variety of mathematical approaches to the expressing of, or to the solving of a physical problem

D. Have a basis for further study of the physical sciences

E. Understand how major developments in physics have affected people and society

II. Content Outline

A. Measurement
  1. Metric units to include meter, kilogram, and liter
  2. Linear measuring devices
    a. Meter stick
    b. Vernier caliper
    c. Micrometer caliper
  3. Balances
  4. Volume determination by displacement
  5. Conversion constants for changing metric units to English units
  6. Precision of measurements and significant digits

B. Mechanics
  1. Uniform motion to include displacement, speed, and velocity
  2. Vector solutions
    a. Graphic
    b. Trigonometric (optional)
  3. Acceleration of rectilinear motion
  4. Acceleration of circular motion
  5. Acceleration of gravity
  6. Derivations and use of uniform motion equations
  7. Projectile motion (optional)
  8. Newton's first law of motion (inertia)
  9. Newton's second law of motion (acceleration)

10. Newton's third law of motion (action-reaction)
    a. Conservation of momentum
    b. Elastic and inelastic collisions
11. Centripetal force
12. Law of universal gravitation
13. Relationship between mass and weight
14. Systems of measurement
15. Composition and resolution of forces
    a. Graphic solutions
    b. Trigonometric solutions (optional)
16. Parallel forces - moment of force
17. Stability
18. Center of gravity
19. Problems involving forces and equilibrium
20. Energy
    a. Types
    b. Measurement
    c. Law of conservation of energy
21. Work
22. Power
23. Friction
    a. Factors which determine the force of friction
    b. Coefficient of friction
24. Boyle's law
25. Bernoulli's principle

C. Matter and energy
1. Structure of atom
2. Structure of molecules
3. The elements and their isotopes
4. Kinetic theory
    a. Basic assumptions
    b. Observations supporting the theory
5. States of matter
6. Properties of matter
    a. General
    b. Special
7. Diffusion of matter
8. Surface tension and capillary action
9. Rest and relativistic masses
10. Energy equivalent of mass
11. Law of conservation of matter - energy
12. Transmutation
    a. Nuclear binding energy
    b. Radioactive decay
    c. Radioisotopes
    d. Artificial radioactivity
    e. Fission
    f. Fusion
13. Cosmic rays
14. Applications of nuclear energy

Physics 424
GRADES ELEVEN AND/OR TWELVE

D. Heat
  1. Heat as a form of energy
  2. Sources of heat energy
  3. Temperature as a measure of heat intensity
  4. Temperature scales
    a. Fahrenheit and Celsius
    b. Kelvin and Rankine
  5. Heat transfer
    a. Convection
    b. Conduction
    c. Radiation
  6. Thermal expansion
    a. Coefficients of expansion
    b. Applications
  7. Measurement of heat energy
    a. Units
    b. Specific heats
  8. Changes of state
    a. Fusion
    b. Vaporization
    c. Solution
    d. Crystalization
  9. Solving heat exchange problems
  10. Gas laws
    a. Charles'
    b. Gay-Lussac's
    c. General gas laws
  11. Heat energy and work
    a. Mechanical equivalent of heat
    b. Laws of thermodynamics
    c. Heat engines (optional)
      1) Reciprocating
      2) Rotary
      3) Reaction

E. Wave motion
  1. Types of waves
    a. Transverse waves
    b. Longitudinal waves
  2. Simple harmonic motion
    a. Circular motion
    b. Pendulum
    c. Weighted springs
    d. Mathematical analysis of simple harmonic motion (optional)
  3. Relations among frequency, velocity, and wavelength
  4. Combining waves
    a. Amplitude
    b. Frequency, including beat frequencies
  5. Wave phenomena
    a. Reflection
    b. Refraction
    c. Interference
    d. Diffraction

    6. Doppler effect

F. Sound
    1. Nature of sound sources
        a. Type of surface which vibrates
        b. Type of vibration
    2. Transmission of sound energy
        a. Types of waves
        b. Physical properties of the transmitting medium
            1) Density
            2) Elasticity
        c. Relation among frequency, velocity, and wavelength
    3. Formation of shock waves
    4. Sound wave phenomena
        a. Reflection
        b. Refraction
        c. Interference
        d. Diffraction
    5. Resonant vibrations
    6. Properties of a musical tone
        a. Physical properties
        b. Sensory properties
    7. Tones and hearing
        a. Harmonics
        b. Combining of tones to form chords
    8. Musical scales (optional)
    9. Musical instruments (optional)
        a. Pipes
        b. Strings
        c. Percussion

G. Light
    1. Nature of light
        a. Electromagnetic radiation
        b. The visible spectrum
        c. Speed of light
    2. The dual theories of light - wave and particle
    3. Interference and diffraction
        a. Interference patterns
        b. Shadow formation
    4. Polarized light
    5. Measurement of light energy
    6. Law of illumination
    7. Law of reflection
    8. Image formation
        a. Plane mirrors
        b. Curved mirrors
    9. Refraction
        a. Index of refraction
        b. Total internal reflection

10. Image formation by lenses
11. Optical instruments (optional)
12. Color
    a. Lights
    b. Pigments
    c. Color vision
13. Spectra
    a. Types
    b. Applications

H. Electricity and magnetism
   1. Separation of electric charges
   2. Coulomb's law
   3. Law of conservation of charge
   4. Use of the electroscope
   5. Electric fields
      a. Field intensities
      b. Energy of an electric field
      c. Potential differences
      d. Capacitors
   6. Define current flow
   7. Measurement of current flow
      a. Mechanical terms
      b. In terms of charge transfer
   8. Electrical resistance
      a. Conductors and insulators
      b. Factors determining resistance
      c. Ohm's law
   9. Direct current circuits
      a. Schematic diagram symbols
      b. Series circuits
      c. Parallel circuits
      d. Combination circuits
      e. Wheatstone bridge circuit
   10. Electric cells (optional)
      a. Electrolysis
      b. Voltaic
      c. Storage
      d. Fuel
   11. Electric power and energy
      a. Watt
      b. Joule and kilowatt-hour
   12. Heat and light from electricity
      a. Converting electric energy to heat energy
      b. Producing light from electric energy
   13. Characteristics of magnets
      a. Domain theory
      b. Classification of materials
      c. Polarity
      d. Magnetic fields
      e. Laws of magnets

14. The earth's magnetic field
15. Electromagnetism
    a. Magnetic field of a current
    b. Field strengths
    c. Electromagnets
16. Charged particles in a magnetic field
    a. Magnetic field of a particle
    b. Field strengths
    c. Applications
17. The motor effect
    a. Types of motors (optional)
    b. Meters
18. Generator effect
    a. Magnitude of induced electromotive force
    b. Induced alternating current
    c. Lenz's law
19. Characteristics of alternating current (optional)
    a. Sinusoidal variation
    b. Effective values of voltage and current
20. Alternating current circuits (optional)
    a. Circuits containing capacitors
    b. Circuits containing inductors
        1) Self-inductance
        2) Lenz's law
    c. Resonant circuits
    d. Transformers
    e. Induction coils

I. Electronics
  1. Cathode ray tube
      a. Controlling the cathode ray
      b. Applications
  2. Charge and mass of an electron
  3. Particle accelerators
      a. Linear accelerators
      b. Cyclotron
      c. Betatron
      d. Synchrotron
  4. Semiconductors
      a. Crystalline structure
      b. Drystal diodes
      c. Transistors
  5. Solid-state physics applications
      a. Thermocouples
      b. Solar cells
      c. Electroluminescent panels
      d. Lasers

III. Concepts to be Taught

A. Kinematics
  1. Complex motions can often be considered as a series of simple motions

2. The simplest kind of motion is uniform motion in a straight line, which is described quantitatively by the equation $s = vt$
3. For motion at constant speed the displacement, or distance traveled, increases steadily as time goes by
4. In uniformly accelerated motion the variables are related to each other by the following equations:

$$a = \frac{v_f - v_i}{t} \qquad s = \frac{vi + vf_t}{2} \qquad v_f{}^2 = v_i{}^2 + 2as \qquad s = v_i{}^t + 1/2at^2$$

5. Motion with constant velocity is a special case of accelerated motion in which $a = 0$
6. The area under the velocity-time graph represents the distance traveled and the slope of the velocity-time graph is the acceleration
7. When the distance-time graph is a curve, the average velocity equals the slope of a chord drawn between two points on the curve. The instantaneous velocity equals the slope of the tangent to this graph drawn through the point representing the time at which the velocity is desired
8. Instantaneous velocity is the limiting value of the average velocity as the time interval approaches zero
9. Vector quantities have both magnitude and direction; scalars have magnitude only
10. The resultant of any number of vectors is found by the head-to-tail rule
11. Components of vectors are found by scale drawings
12. The motion of a projectile may be regarded as two motions that are independent and yet simultaneous. In the absence of air resistance, the vertical motion is uniformly accelerated, and the horizontal motion is one of constant velocity

B. Dynamics

1. Forces can cause motion but they are not always correlated with motion
2. Newton's first law of motion - a body remains at rest or, if in motion, it remains in uniform motion with a constant speed in a straight line, unless acted upon by an unbalanced force
3. Newton's second law of motion - the acceleration produced by an unbalanced force acting on a body is proportional to the magnitude of the net force, in the same direction as the force, and inversely proportional to the inertial mass of the body
4. Inertial mass of a body is determined by measuring its rate of acceleration by a known force
5. Gravitational mass of a body is determined by comparing it with a known mass on a balance
6. Gravitational mass is proportional to inertial mass and the constant of proportionality can be set at unity to obtain the same measuring units for each
7. The weight of a body is the force of gravity on it and can be measured by suspending the body from a spring balance

8. A body's weight is proportional to its mass where g is the constant of proportionality, $W = mg$
9. At the earth's surface g - 9.8 N/kg; a 1 kg mass weighs 9.8 N. g also represents acceleration due to gravity; at the earth's surface it is 9.8 m/sec^2
10. Newton's second law applies to a complete system (group of bodies) or to a body within a system. It is often helpful to isolate bodies in problem-solving
11. Newton's third law of motion - for every action there is an equal and opposite reaction
12. An action-reaction pair of forces can be identified by reading the description of one of the forces backward, thereby describing the other
13. Action and reaction forces always act on different bodies
14. A frame of reference is a point, or coordinate system, from which various motions are viewed. The observer's frame of reference is thought of as being at rest
15. An inertial frame of reference is one in which Newton's laws of motion are valid
16. To apply Newton's laws in a noninertial, or accelerated frame of reference

C. Conservation of energy
  1. Energy can be transformed from one form (electric for example) to another (mechanical or light)
  2. Energy is transferred from one place to another
  3. The law of conservation of energy states that the energy content of an isolated system (a system not acted upon by external forces) remains constant
  4. Work is done when a force acts through a distance
  5. Quantitatively, work is the product of force-times distance moved $W = F(s)$
  6. No work is done if no motion is involved no matter how much force is applied, and no work is done if there is no force component along the direction of the motion
  7. Units of work are the product of force and distance units:
    a. 1 joule = (1 newton) (1 meter)
    b. 1 erg = (1 dyne) (1 centimeter)
  8. The amount of work done is a measure of how much mechanical energy has been transferred
  9. Potential energy is the energy of a system of bodies due to the relative position of the parts of the system, $PE = mgh$
  10. Kinetic energy is the energy of a body due to its motion, $KE = 1/2mv^2$
  11. In a system such as a swinging pendulum, mechanical energy is conserved. Total $PE + KE$ is constant
  12. The mass of a body depends on its velocity relative to the observer. As the velocity increases, a body's mass approaches infinity
  13. The importance of the law of conservation of energy lies in the fact that it includes all forms of energy and mass energy as well
  14. Rest mass is measured at rest relative to the observer

15. Mass and energy are equivalent according to the Einstein equation,

    $\Delta E = (\Delta m)\, c^2$

16. The relativistic mass of a body is measured by an observer when there is relative velocity between the mass and the observer

D. Conservation of momentum
   1. The momentum of a body is defined as the product of its mass and its velocity
   2. Newton's second law, in terms of momentum, states that net force equals rate of change of momentum, net $F = \frac{\Delta(mv)}{t}$
   3. Momentum should be considered in combination with Newton's third law (action-reaction pairs)
   4. Since velocity is a vector quantity, momentum is also
   5. An impulse is the product of net force and the time during which it acts
   6. After an explosion of a body initially at rest, the total momentum of all particles is equal to zero
   7. The total momentum before a collision equals the total momentum after the collision
   8. The center of mass is the point at which all the mass of a body can be considered to be concentrated when using Newton's second law
   9. The center of mass of a multi-bodied system at rest remains in the same place after the bodies are separated by an explosion
   10. When two bodies interact in an inelastic collision, some KE is permanently lost
   11. When two bodies interact in an elastic collision, no KE is lost
   12. The laws of conservation of energy and conservation of momentum are derived from Newton's laws of motion and are applicable in modern, as well as classical physics

E. Circular motion
   1. Free fall is the motion of a body under gravitational force alone
   2. A projectile in free fall moves in a curved path whenever the force of gravity on it has a component perpendicular to the direction of motion
   3. A constant force acting at right angles to the motion of a body causes it to move in a circle at constant speed
   4. In uniform circular motion the magnitude of the velocity is constant, but the direction of the velocity changes
   5. Centripetal acceleration is directed inward along the radius of a circle
   6. The force that produces uniform circular motion is centripetal force
   7. Any type of force can serve as centripetal force, such as gravitational force of the sun on the planets
   8. Newton's law of universal gravitation - everybody in the universe attracts every other body with a force that is directly proportional to the product of the masses of the two bodies, and inversely proportional to the square of the distance between them

9. The actual weight of a body depends on its position in the gravitational field

F. Simple harmonic motion

1. The restoring force in SHM is described as $F = -kx$
2. The restoring is proportional to acceleration in SHM
3. We have SHM whenever the acceleration is proportional to the negative of the displacement $a^x - x$
4. The period T of SHM is the time for one complete vibration, and is given by $T = 2\pi \sqrt{m/k}$. The frequency is given by $f = 1/T$
5. Hooke's law refers to the equal and opposite force (to the restoring force), called the distorting force, exerted by a mass on a spring. In these terms then, $F = kx$
6. The projection of uniform circular motion upon any straight line is SHM
7. The speed v of a reference particle on the circumference of the circle equals the maximum velocity of a particle in SHM as it passes through the center, $v = 2\pi A/T$

G. Wave motion

1. Periodic waves occur when disturbances are repeated at regular intervals
2. Shock waves or pulses result from a single disturbance and are not repeated
3. Wave speed is affected by the compressibility and density of the medium
4. In longitudinal waves the displacement is parallel to the direction of propagation
5. With transverse waves, the displacement is at right angles to the direction of propagation. Electromagnetic waves are transverse waves
6. If the displacements of transverse waves are all in the same plane, they are plane polarized. Only transverse waves can be polarized
7. A vibration is a motion of a single particle of some medium only; a wave transmits a disturbance from place to place by coupling together the vibrations of many neighboring particles
8. The period T is the time for one complete vibrations of any given particle of the medium. The frequency f is the number of vibrations per unit time for any particle, usually measured as so many cycles per second, or hertz (Hz). As with any SHM, the frequency is inversely related to the period, that is $f = \frac{1}{F}$
9. The amplitude A is the maximum displacement of any particle, measured from its equilibrium or undisturbed position
10. The wavelength λ is the distance between any two successive particles that have the same phase. The wave velocity v_w is the velocity with which any specific phase of the motion (crest, trough, etc.) is propagated through the medium. An important relation is wave velocity = frequency x wavelength $v = f\lambda$
11. Sound waves are longitudinal waves consisting of regions of compression and rarefaction

H. Temperature and expansion
   1. Various thermometric properties of matter may be used to define temperature scales
   2. When solids expand or contract, the change of length is proportional to the original length and change in temperature, according to the equation $\Delta l = alAt$. The factor α is the coefficient of linear expansion
   3. A change in the volume of a solid, liquid, or gas is given by $\Delta V = \beta V \Delta t$, where β is the coefficient of volume expansion
   4. All gases have approximately the same coefficient of volume expansion
   5. The coefficient of expansion of solids and liquids differs significantly with the kind of substance

I. Heat and thermal energy
   1. Heat flow is a measure of thermal energy change as work is a measure of mechanical energy change
   2. The thermal energy, or internal energy of a body involves the motions of its molecules
   3. The specific heat of a substance is the heat absorbed or given off per unit of mass per unit change of temperature
   4. The first law of thermodynamics is a modification of the law of conservation of energy to include thermal energy
   5. When heat flows into a body the internal energy of the body increases in one or both of two ways: increase of random KE of molecules and increase in PE of the molecules
   6. If the random KE of the molecules increases, the temperature rises; if the PE increases, the temperature does not rise and heat absorbed is called latent heat

J. Thermal behavior of gases
   1. An ideal gas is one in which the molecules exert no appreciable cohesive forces. The molecules are small in size compared with the space between them
   2. To a large extent these conditions are fulfilled by practically all gases at ordinary temperatures. Therefore, all gases observe the same gas law regardless of chemical composition
   3. Pressure is defined as force per unit area
   4. According to Boyle's law, when the mass and termperature are constant, the pressure is inversely proportional to the volume of a gas $P = \frac{1}{V}$
   5. The change in pressure of a confined gas is directly proportional to the change in temperature - volume and mass remaining constant
   6. The temperature at which the pressure of an ideal gas would become zero is called absolute zero, $-273^{\circ}C$. This value of absolute zero is extrapolated since the gas would no longer be an ideal gas at that temperature
   7. The form of the general gas law is simplified by using the Kelvin or absolute temperature scale which is equal to Celsius temperature plus 273°

8. Boyle's law is a special case of the general gas law, as are $\frac{P}{T}$ = constant and $\frac{V}{T}$ = constant

K. Theory of heat
   1. Thermal energy is total internal energy including the KE and PE of all molecules
   2. The absolute temperature of an ideal gas is proportional to the average random translational KE per molecule
   3. The pressure exerted by molecules of a gas can be computed from Newton's second law, and this allows determination of molecular speeds from observed data on temperature, pressure, and volume
   4. At any given temperature, molecular speeds are less for molecules of greater mass, since the average KE's of the molecules of all gases are the same at any given temperature
   5. The first law of thermodynamics - all heat added to a closed system can be accounted for as mechanical work as increase in thermal energy or both. The first law of thermodynamics is an extension of the law of conservation of energy, including thermal energy along with the mechanical energy
   6. The second law of thermodynamics may be stated in several ways
      a. Heat tends to flow from a hot place to a cold place
      b. Energy tends to become more and more unavailable for conversion from thermal energy to mechanical energy
      c. The entropy of the universe tends toward a maximum
   7. Entropy, the unavailability of energy, is a measurable property of a body

L. Electric forces
   1. Coulomb forces always exist between charges whether they are at rest or in motion
   2. Magnetic forces only exist between charges in motion relative to each other
   3. There are two kinds of electric charge, now called positive and negative
   4. Like charges repel each other; unlike charges attract each other. Charges can be transferred from one object to another by rubbing
   5. Charges flow easily through metals which are good conductors. Substances through which charges do not flow readily are insulators
   6. Electric forces act over a distance and can induce charges in objects without being in direct contact. This is called charging by induction
   7. When charges become separated by contact, equal amounts of positive and negative charges are produced
   8. Coulomb's law - the electrostatic force between two charges is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them. Expressed in symbols, $F = k \frac{QQ'}{l^2}$

M. Electric energy

1. In a metal wire electric current is the net transfer of positive charge resulting from the movement of electrons (negative charges) through the wire
2. In a liquid electrolyte, both positive and negative charges are free to move
3. Nonelectric energy is converted into electric energy in a source of emf
4. Emf and PD are both measured in volts V. Emf refers to the conversion of energy while PD refers to the difference in potential between any two points of an electric system
5. A resistor is a conductor in which electric energy is dissipated as heat
6. Joule's law states that the rate of production of thermal energy (power) in a metallic resistor is proportional to the square of the current. Mks units for power and resistance are respectively the watt W, and the ohm Ω
7. Ohm's law for part of a circuit is valid only for metallic resistors at a definite temperature carrying a steady current. It states that the PD between any two points in a circuit equals the product of the current and the resistance

N. Electric fields

1. The strength of an electric field E is defined as the force on a test charge divided by the magnitude of the test charge $E = F/Q$. This is similar to the gravitational field strength
2. Vector fields, such as electric and gravitational fields, and those that describe the velocity of moving air or water, can be measured for magnitude and direction at any point in the field
3. Lines of force originate on positive charges and terminate on negative charges even though they may be a great distance away. The density of the lines can be used to indicate field strength
4. There is a change in potential per unit distance from the source of the field. This is called the potential gradient. The direction of the field is always in the direction of decreasing potential
5. A practical application of the concept of electric field is the capacitor consisting of two adjacent, nontouching conductors with equipotential surface, a PD existing between the surfaces
6. For any given pair of conductors, the ratio Q/V is a constant called the capacitance, C, measured in farads F in the mks system
7. The medium between the conductors (if any) is a nonconductor called the dielectric. The dielectric constant K is the ratio of the capacitances with the medium and with a vacuum between the plates
8. Capacitors are used in a circuit for temporary storage of charge and for variable tuning in radio and TV
9. When capacitors are connected in parallel in a circuit the equivalent capacitance is the sum of the individual capacitances: $C_p = C_1 + C_2 + C_3 + \ldots$

O. Electric circuits

1. A cell has internal resistance; therefore, its terminal voltage V need not equal the emf. For a cell supplying energy, $V = E - Ir$. For a cell being charge $V = E + Ir$
2. For resistors connected in series, the total energy dissipated equals the sum of the energies dissipated in the individual resistors, therefore, $R_s = R_1 + R_2 + R_3 + \ldots$

   For resistors in parallel, $\frac{1}{R_p} \quad \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$
3. The reciprocal of resistance is conductance, a measure of how easily a current can flow through a resistor
4. Circuits can be simplified and more easily understood by substituting a single resistance for a combination of resistors
5. The amount of energy lost or gained by a charge passing through emf sources connected in a series is the algebraic sum of the energy lost or gained in passing through each of the sources
6. If sources of emf are connected in parallel when the emfs are identical, the net emf equals the emf of each cell. When the emfs are not identical, the net emf cannot be computed easily
7. Ohm's law takes a special form for a complete circuit. The current through a circuit equals the net emf divided by the net resistance of the circuit
8. The total energy per unit charge taken out of a circuit by dissipation into heat and by the charging of cells must equal the non-electric energy converted into electric energy in the sources of emf (variation of main concept)
9. In the galvanometer, a coil in a magnetic field is deflected in proportion to the current through the coil
10. The ammeter is a variation of the galvanometer used for larger currents in which excess current passes through a resistor connected in parallel with the meter (a shunt)
11. The voltmeter is a variation of the galvanometer for reading higher voltages in which excess energy is dissipated in a resistor connected in series with the meter (a multiplier)
12. A potentiometer can measure the true emf of a cell by balancing the curcuit so the current through the cell becomes zero

P. Electromagnetism

1. Magnetic forces are extra forces due to motion over and above any Coulomb forces
2. Electrons traveling in a straight line are sometimes deflected by a magnetic field
3. The magnetic force F on a moving charge is perpendicular to the direction of motion v, and for maximum force, the motion of the charge must be perpendicular to the direction of the field B
4. The force F on a current segment in a magnetic field B is greatest if the current I is perpendicular to the field

5. A current, or moving charges, in a wire, is a source of a magnetic field. The direction of the field about a straight wire carrying a current can be determined by the right-hand rule
6. The magnetic field at a point P, a distance, a, from a very long straight wire, is directly proportional to the current and inversely proportional to the distance, a, thus $B = k' I/a$
7. One ampere is the current in a long straight wire that exerts a force of exactly 2×10^{-7} newtons per meter on a neighboring long parallel wire, 1 meter distant, that carries an equal current
8. An emf can be induced in a conductor that is moved in a suitable direction across a magnetic field. This is the principle of an electric generator
9. The induced emf equals the product of the field strength B, the length of the wire l, and the velocity across the lines of force (that is, perpendicular to the field), $\mathcal{E} = Blv$
10. Lenz's law gives the direction of the current resulting from an induced emf - an induced emf tends to set up a current whose action opposes the change that caused it

Q. Electromagnetic radiation
1. The spectrum of electromagnetic radiation includes everything from radio waves of low frequency to high frequency x-rays and gamma rays
2. Both a wave and corpuscle model have been used for light. Scientists have looked for experimental results that can be described by one model and not the other. Our modern view combines features of both
3. Electric oscillations are analogous to the mechanical oscillation of a spring
4. Only the relatively slow vibrations of radio waves are produced when charges are set into oscillation by purely electric means
5. Many electric oscillators use coil and capacitor circuits (often called LC circuits), whose frequency is given by $f = (1/2 n)\sqrt{1/LC}$
6. Infrared, visible, ultraviolet, x-ray and gamma ray radiations are connected with acceleration of charge, but the wave model is not entirely adequate to describe the emission of high frequency radiation
7. A changing electric field gives rise to an induced magnetic field and vice versa
8. The interaction between electric and magnetic fields allows the propagation of electromagnetic waves in which electric and magnetic fields are perpendicular to each other, and both are perpendicular to the direction of propagation
9. Electromagnetic waves are transverse and may be plane polarized. Their velocity in a vacuum is 3×10^{8} m/sec. The wave velocity c is related to frequency f and wavelength λ as follows: $c = f\lambda$

R. Wave fronts
1. When a ray of light strikes a smooth surface, it is reflected and the angle of incidence is equal to the angle of reflection
2. If the surface is not perfectly smooth, diffuse reflection takes place and the light rays are scattered

3. When light rays pass into a different medium, they are bent or refracted, due to the difference in velocity in the two mediums
4. Rays of light passing from a denser medium into a medium that is less dense are partially or totally reflected from the surface. If the angle of incidence is greater than a certain critical angle total reflection occurs
5. Lenses cause rays of light either to converge or diverge. With converging, or convex, lens, rays may come together at a mathematical point called a focus. Rays parallel to the axis of the lens come together at the principal focus
6. The distance between the center of the lens and the principal focus is the focal length
7. A positive lens converts straight wave fronts into converging, or positive, wave fronts. A negative lens converts plane wave fronts into diverging, or negative, wave fronts
8. A lens' power is the effect it has on the curvature of a wave front and is equal to the reciprocal of its focal length, $\frac{1}{f}$. The power depends on the curvature of the surface and on the index of refraction of the glass. The lens formula states that the original curvature of the wave front plus the power of the lens equals the final curvature of the wave front
9. The size of an image is found from a proportion

$$\frac{\text{image size}}{\text{object size}} = \frac{\text{image distance}}{\text{object distance}}$$

10. When a plane wave strikes a concave mirror, it becomes converging and forms a real image at a principal focus, F, and a virtual image only if the object is within the principal focus

S. Wave nature of light
1. Newton's corpuscular model explained many aspects of the behavior of light. It assumed, however, that the velocity of light in a denser medium was greater than in air. This was later proven to be untrue
2. Young's experiment with interference of light from two in-phase sources provided strong evidence for the wave model
3. The interference pattern from two point sources shows areas of constructive interference (maximums) and destructive interference (nodal lines)
4. Maximums occur whenever the path difference from the two sources is whole wavelengths λ, 2λ, 3λ, and so forth

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

PROJECT PHYSICS 425

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Project Physics 425
Not Grouped
GRADES ELEVEN AND/OR TWELVE

This elective course offers one credit toward graduation. Upon successful completion of the course, the student will demonstrate an understanding of the following:

I. Instructional Objectives

   A. The role played by science in the history of people

   B. A humanistically oriented physical science course

   C. The basic, uniting principles of physical science which serve to give continuity to scientific endeavor

   D. The inter-relationships of society, government, church and science, both past and present

   E. The historical continuum of the works of individual scientists

   F. Some current society-science issues

   G. Science as a many-sided human activity with historical and cultural aspects included as a part of scientific discovery

   H. A positive attitude toward science as a tool of society

   I. A variety of laboratory experiences to discover, reinforce, and/or verify physical laws

   J. A variety of mathematical approaches to the expressing of, or to the solving of a physical problem

   K. The basis for further study of the physical sciences

II. Content Outline

   A. Starting an answer to "how do things move?"
      1. Meaning of motion
         a. Straight line
         b. Circular
      2. Speed of motion
      3. Distance measured as a function of time
      4. Meaning of average speed
      5. Graphing motion
         a. Format
         b. Size
         c. Scales
         d. Techniques

6. Interpolation and extrapolation of graphs - uncertainties with the use of either method
7. Instantaneous speed
    a. Graphical respresentation
    b. A conceptual invention
8. Acceleration

B. Galileo's study of free fall
1. Aristotelian physics of motion
2. Galileo's work with motion related to Aristotelian physics
3. The choosing of free fall to study
4. Uniform acceleration defined in terms of distance, d/t^2 is a constant
5. Free fall motion extrapolated from Galileo's work with the inclined plane
6. Doubts raised concerning Galileo's procedure
7. Consequences of Galileo's work with motion

C. Newton's laws of motion
1. Overview of Newtonian mechanics as an explanatory system of dynamics
2. Aristotelian vs. Newtonian mechanics
3. Equilibrium of forces
4. Vectors and vector solutions
5. Newton's laws of motion
    a. Inertia
    b. Acceleration
    c. Action-reaction
6. Relationships of and distinctions between mass, weight, and free fall
7. Nature's basic forces; four basic interactions

D. Adding understanding to motion
1. Uniformity, symmetry, and dimensionality as related to a trip to the moon
2. Projectile motion
3. Path of a projectile
4. Moving frames of reference
5. Uniform circular motion; simple harmonic motion
6. Centripetal acceleration and centripetal force
7. Earth satellites

E. Motion and astronomy (where is the earth?)
1. Heavenly motions
    a. Sun
    b. Stars
    c. Moon
    d. Planets
2. The ancient Greeks' meaning of explanation
    a. Model building
    b. Hypotheses
3. Ancient Greek model(s) of the universe (earth-centered)

   4. An ancient Greek sun-centered model
   5. The Ptolemaic, geocentric system of heavenly motions

F. Contributions of Copernicus and Tycho Brahe
   1. The Copernican model of the universe
   2. New conclusions based on the Copernican model
   3. Arguments for and against the Copernican model
   4. The Copernican model as a basis for further investigation and later models
   5. Brahe's contributions - accurate observations and a compromise model

G. Contributions of Kepler and Galileo
   1. The abandonment of uniform circular motion, the ancient Greek's promise
   2. Kepler's laws
      a. Areas
      b. Elliptical orbits
      c. Periods
   3. Observations, not mystical interpretations, as a basis for physical laws
   4. Galileo's works
      a. Telescopic evidence
      b. Widely read writings
   5. Science and freedom: Galileo vs. the church

H. The work of Newton
   1. Acceptance of empirical, experimental science
   2. Newton's Principia
   3. The inverse-square law of planetary force
      a. An extension of Kepler's work
      b. Motion controlled by a central force
   4. Law of universal gravitation
      a. Hypotheses
      b. Magnitude of force
      c. Gravitational constant
   5. $\underline{G}$ and the actual masses of planets
   6. Further applications of Newton's gravitational law - tides and comets
   7. Effects and limitations of Newton's work

I. Conservation of mass and momentum
   1. Initial generalizations and applications of Newtonian mechanics
   2. Conservation of mass
   3. Collisions
   4. Conservation of momentum
      a. Momentum related to laws of motion
      b. Isolated systems
   5. Conservation of kinetic energy and definition of elastic collisions
   6. Leibniz and the conservation laws - the role of philosophers

J. Energy
   1. Work and kinetic energy
   2. Potential energy

3. Conservation of mechanical energy
4. Forces that do no work
5. Heat energy and the steam engine
6. Industrial revolution
    a. Watt's work
    b. Joule's experiments
7. Energy in biological systems
8. General energy conservation law
    a. Input by many scientists
    b. Mathematically precise statement: $\triangle E = \triangle W + \triangle H$
    c. Faith in law predicts new observations

K. Kinetic theory of gases
    1. Newtonian mechanics applied to gases
    2. A model of the gaseous state
    3. Molecular speeds and sizes
    4. Predictions based on the kinetic theory model
    5. Dissipation of energy
        a. Entropy
        b. Disorder
    6. Statistical view of the second law of thermodynamics
    7. Time's direction
        a. Recurrence
        b. Reversibility

L. Waves
    1. Wave properties
    2. Wave propagation
    3. Periodic waves; simple harmonic motion
    4. Superposition principle
    5. Wave phenomena
        a. Two-source interference
        b. Standing waves
        c. Diffraction
        d. Reflection
        e. Refraction
    6. Sound waves

M. Light
    1. Physical optics - interference, diffraction, polarization, used to test theories
    2. Propagation of light
    3. Reflection and refraction
        a. Wave vs. partical models
        b. Snell's law
    4. Interference and diffraction
    5. Color
    6. Scattering
    7. Polarization
    8. Ether

N. Electric and magnetic fields
  1. Basis for electromagnetic wave theory established
  2. Work of Gilbert
  3. Electric charges and electric fields
  4. Forces and fields
  5. The elementary charge
  6. Electric currents and electric potential differences
  7. Ohm's law
  8. Electric potential difference and power
  9. Interactions of currents and magnets
  10. Interactions of magnetic fields and moving charges

O. The work of Faraday
  1. Applications of technology
    a. Faraday
    b. Oersted
    c. Ampere
    d. Henry
    e. Edison
  2. Electromagnetic induction
  3. The dynamo - a generator
  4. Electric motor
  5. Edison and the electric light bulb
  6. AC vs. DC
  7. Electricity and society

P. Electromagnetic radiation
  1. The work of Maxwell
  2. Propagation of electromagnetic waves
  3. Hertz's experiments
  4. Electromagnetic spectrum
    a. Relationships to earlier topics
    b. Common characteristics
  5. The ether
    a. Michelson and Morley
    b. Einstein

III. Concepts to be Taught

A. Conservation
  1. Terrestrial motions - the pattern of development of earthly motions included:
    a. Aristotelian mechanics and the order of natural forces and positions
    b. Galilean kinematics with the introduction of experimentation and mathematical formulation
    c. Newton's laws of motion which extended experimentation
    d. Newton's synthesis of dynamics leading to universality of gravity, laws of motion, and a mechanistic model of the universe

2. Celestial motions - paralleling the development of earthly mechanics was a series of models for the heavens which included:
   a. The ancient Greek model based on Aristotelian mechanics of natural order and heavenly perfection
   b. The Ptolemaic model of the universe which was quite a complete and accurate geocentric model
   c. The Copernican model of the universe which adapted the Ptolemaic model to a heliocentric model
   d. The Keplerian model which was a departure from the Copernican model in that Kepler's laws were emperical and motions were elliptical
3. Conservation of momentum - terrestrial and celestial mechanics result in a "quantity of motion" that is a constant for a single system. This "quantity of motion" momentum is defined as the product of mass and velocity. Conservation of momentum is a logical consequence of Newton's second and third laws of motion
4. Conservation of mechanical energy - the capacity to produce changes in motion due to a body's position and/or condition of motion is also quantitative and is conserved. The form may change from kinetic energy to some form of potential energy; the total for a system is a constant
5. Conservation of total energy - heat energy and energies stored in magnetic and electrical fields can produce mechanical changes. Energies may be transformed from one kind to another; the total of all types of energies for a system is a constant. Laws of thermodynamics and of electromagnetism support this conservation law

B. Electromagnetism
   1. Electric and magnetic phenomena - observable phenomena of an electric and/or magnetic nature lead to a series of relationships (laws)
      a. Magnetic forces of attraction and repulsion (Gilbert)
      b. Electric forces of attraction and repulsion (Coulomb)
      c. Forces of interaction of magnetic fields and currents (Oersted and Faraday) result in electromagnetic induction laws
   2. Light phenomena
      a. Phenomena of reflection and refraction lead to laws of reflection and refraction and to a particle model of light
      b. Phenomena of diffraction and interference lead to a wave model of light to describe each
   3. Maxwell's principle - These principles formulate the interdependence of changing electric fields and changing magnetic fields
   4. Electromagnetic radiation - the extension of Maxwell's equations unify magnetic fields, electric fields, visible radiation, and the spectrum of energies to include radio waves and gamma rays

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

BIOLOGY 451

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Biology 451
Advanced Placement
GRADES ELEVEN AND/OR TWELVE

Advanced placement biology represents a general biology course on the college level. Successful completion of the course enables the student to take the AP exam in May and to receive college credit and/or placement.

I. Instructional Objectives

- A. The student should develop an understanding of the unity and diversity in living things at the molecular, cellular, organismal, and populational level
- B. The student should develop an understanding of evolution as an explanation of unity and diversity
- C. The student should develop an understanding of homeostasis as a basic biological phenomenon and how homeostatic mechanisms involving feed-back control operate in plant and animal organ systems
- D. The student should develop an understanding of the means by which biological information is collected, how it is interpreted, and how one formulates hypotheses from available data and makes further predictions
- E. The student should become familiar with the evidence that supports the major concepts in biology
- F. The student should develop an understanding of science as a human endeavor with social consequences

II. Content Outline

- A. Basic chemistry
  - 1. Atoms and isotopes
  - 2. Chemical bonds
  - 3. Chemical reactions and equilibria
  - 4. Energetics: free energy change and entropy
  - 5. Chemical composition of organisms
    - a. Principal elements in organisms
    - b. Properties of water
    - c. Chemical structure of important organic substances
      - 1) Carbohydrates
      - 2) Lipids
      - 3) Proteins
      - 4) Organic acids
      - 5) Nucleic acids

- B. Cells
  - 1. Historical development of the cell concept

2. Cell ultrastructure
    a. Role and limitations of biochemistry, centrifugation, and microscopy (light and electron) in understanding cells
    b. Structure and function of cell organelles
    c. Cell (plasma) membrane and its properties
    d. Comparison of prokaryotic and eukaryotic cells

C. Enzymes
    1. Enzyme-substrate complex
    2. Role of coenzymes, inorganic cofactors, and prosthetic groups
    3. Factors affecting the rate and/or direction of enzyme reactions

D. Energy transformations
    1. Aerobic and anaerobic respiration
        a. Chemical structure and function of ATP
        b. Pathways of aerobic respiration
            1) Krebs cycle
            2) Cytochrome (electron) transport system
        c. Pathways of anaerobic respiration
            1) Glycolysis
            2) Fernmentation
        d. Sites of respiratory enzymes
        e. Factors affecting the rate of respiration
    2. Photosynthesis
        a. Historical developments
        b. Factors affecting the rate of photosynthesis
        c. Role of pigments and plastids
        d. Absorption spectra and action spectra
        e. Nature and interrelation of light and dark reactions
        f. Comparison between respiration and photosynthesis

E. Cell division
    1. Structure of chromosomes
    2. Mitosis and meiosis in plants and animals
    3. Cytokinesis in plants and animals; control of cell division

F. Chemical nature of the gene
    1. Watson-Crick model of nucleic acids
    2. Self-copying of DNA molecule
    3. Genetic code and chemical nature of mutation
    4. Control of protein synthesis: transcription and translation
    5. Gene regulation: structural and regulatory genes
    6. Principles of transformation and transduction

G. The origin of life
    1. Modern theories
    2. Experimental evidence

H. Structure and function in plants with emphasis on angiosperms
    1. Root, stem, leaf, flower, seed, and fruit
    2. Water and mineral absorption and transport
    3. Food translocation and storage

Biology 451
GRADES ELEVEN AND/OR TWELVE

I. Plant reproduction and development
  1. Alternation of generation of fern, pine, and flowering plants
  2. Gamete formation and fertilization
  3. Seed structure and germination
  4. Growth and development including hormonal control: auxins, kinins, gibberellins, and other phytohormones
  5. Tropism and photoperiodicity
  6. Experimental analysis of plant development

J. Structure and function in animals with emphasis on vertebrates
  1. Major systems: digestive, respiratory, circulatory, excretory, sketal, muscular, and nervous
  2. Homeostatic mechanisms
    a. Neural controls in homeostasis
    b. Hormonal controls in homeostasis
  3. Hormones in reproduction
    a. Hormonal control of gamete production
    b. Hormonal control of uterine changes in mammals

K. Animal reproduction and development
  1. Gamete formation and fertilization
  2. Cleavage, gastrulation, and germ layer formation
  3. Differentiation of organ systems
  4. Experimental analysis of vertebrate development
  5. Extraembryonic membranes of vertebrates
  6. Formation and function of the mammalian placenta
  7. Pattern of circulation in a human embryo and the changes occurring at birth

L. Principles of heredity
  1. History of early experiments in heredity
  2. Mendelian inheritance: dominance, segregation, independent assortment
  3. Probability
  4. Chromosomal basis of inheritance
    a. Sex determination
    b. Chromosomal abnormalities: Klinefelter's syndrome, Down's syndrome, Turner's syndrome, and others
  5. Linkage
  6. Sex-linked, sex-influenced, and sex-limited inheritance
  7. Polygenic inheritance: height and skin color
  8. Multiple alleles, human blood groups

M. Principles of ecology
  1. Energy flow and productivity in ecosystems
    a. First and second laws of thermodynamics
    b. Food chins and webs
    c. Trophic levels and pyramids
    d. Primary productivity: magnitude, rates, efficiency
  2. Biogeochemical cycles, such as nitrogen, carbon, and phosphorous
  3. Population growth and regulation in organisms: factors such as natality, mortality, migration, and density

4. Community structure, growth, and regulation
    a. Structure and diversity of ecological communities; major biomes
    b. Succession and climax communities
5. Habitat
    a. Abiotic factors: chemical (e.g., pH, minerals) and physical (e.g., temperature, moisture)
    b. Biotic factors: competition, predation, mutualism, commensalism, and parasitism
6. Concept of niche

N. Principles of evolution
1. History of evolutionary concepts: Lamarckian and Darwinian theories
2. Modern concept of natural selection - differential reproduction
    a. Mutation
    b. Hardy-Weinberg equalibrium
    c. Factors affecting Hardy-Weinberg equilibrium
3. Speciation
    a. Genetic changes in populations
    b. Role of geographic barriers
    c. Reproductive isolating mechanisms
4. Adaptive radiation
5. Evolutionary diversity
    a. Major features of plant and animal evolution
    b. Concepts of homology and analogy
    c. Convergence
    d. Extinction
6. Concepts of balanced polymorphism and genetic drift
7. Classification of living organisms
    a. Systems of classification
    b. Significance of classification scheme
8. Evolutionary history of people

O. Principles of behavior
1. Stereotyped and learned behavior
2. Biorhythms
3. Societies: ants, bees, birds, and primates
4. Social behavior
    a. Communication and signals
    b. Dominance hierarchy
    c. Territoriality
    d. Aggression
    e. Courtship and parental behavior

P. Social biology
1. Problem of human population growth
    a. Age structure and composition
    b. Birth and fertility rates
    c. Theory of demographic transition
2. People's intervening role in nature
    a. Resources and their management
    b. Pollution: air, water, soil, pesticide, herbicide, radioactive, and thermal

    c. Technology and its environmental implications
3. Implications of biomedical progress
    a. Control of human reproduction
    b. Genetic engineering and genetic counseling

III. Concepts to be Taught

A. Biochemistry

1. Both living and nonliving matter is made up of the same fundamental particles. The only difference is in the way these basic materials are organized
2. All the complex organic molecules are composed of many simpler molecules, bonded together by condensation reactions; they can be broken down by hydrolysis
3. The amino acid content and sequence determine the three-dimensional shape of proteins. Alteration of a protein shape can lead to a change in its biological function
4. Enzymes are proteins that catalyze reactions within organisms and their activity depends on their three-dimensional shape
5. All living systems have a tendency toward increasing disorder; the cell must constantly expend energy to maintain its organized state
6. Cells must have a continuous supply of energy to replace the reduction of the free energy of the system
7. The ultimate energy source for organisms is sunlight. Green plants transform light energy into chemical energy which can be used by other organisms
8. The potential energy stored in organic molecules must be transformed into ATP in order to be used by cells. A greater amount of this potential energy will be transformed into ATP if oxygen is present

B. Cells

1. All living things are composed of cells and all cells arise from pre-existing cells
2. Materials necessary for the life of a cell must be obtained from the environment and waste products must be released into it

C. Cellular reproduction and Mendelian inheritance

1. When a cell divides it makes a complete copy of the genetic information and one complete set goes to each daughter cell
2. When gametes are produced the chromosome number is reduced by half and when fertilization occurs the normal diploid number is restored
3. Sexual reproduction increases variation in the population by making possible genetic recombination
4. A gene is a locus on a chromosome that exerts control over one or more organismal characteristics
5. The expression of a gene depends both on other genes present and the environment
6. Genes do not alter one another but remain distinct and segregate unchanged when meiosis occurs
7. The inheritance patterns for characteristics controlled by genes on the X- chromosome are different from those controlled by autosomal genes

Biology 451
GRADES ELEVEN AND/OR TWELVE

D. Molecular genetics
   1. DNA is the genetic material and can replicate itself. It controls the functioning of all cells by directing protein synthesis
   2. The sequence of bases in DNA determines the amino acid sequence in proteins. This base sequence is a code in the form of 3 nucleotides for each mino acid
   3. The code is degenerate, non-overlapping and universal
   4. Control mechanisms determine which genes are turned on or off and therefore, which M-RNA will be made

E. Development
   1. Development begins with fertilization of an egg by a sperm and proceeds in an irreversible pattern
   2. The developmental process includes cell division, growth, differentiation, and morphogenetic movements
   3. The cytoplasm and cellular environment determines which genetic potentialities are expressed in each cell
   4. As differentiation continues the environment of neighboring cells is altered through chemical secretion and this affects gene activity

F. Physiology and anatomy
   1. The evolutionary development of multicellularity permitted morphological and physiological specialization of different cells for different functions
   2. Heterotrophs depend on nutrients synthesized by autotrophs and must digest these nutrients into smaller molecules before their cells can absorb them
   3. Extracellular digestion is the general rule in multicellular annuals
   4. Gas exchange between a living cell and its environment always takes place by diffusion across thin, moist cell membranes
   5. Most organisms require a transport system to rapidly distribute gases and other substances from the surface to the internal cells or from one part of an organism to another
   6. Organisms have various mechanisms for maintaining a relatively constant internal environment despite changes in the extreme environment
   7. Plant cells can withstand greater changes in their extra cellular fluid than animal cells
   8. Animals utilize various mechanisms for eliminating metabolic wastes and regulating salt and water balance
   9. Hormone control mechanisms coordinate many of the functions of plants and animals including growth and development
   10. The evolution of nerve and muscle tissue with their capacity for rapid response was basic to the evolution of multicellular animals
   11. Animals with more advanced nervous systems have more complex pathways, a greater degree of centralization, and better developed sense organs than animals with simple nervous systems
   12. The major evolutionary change in the vertebrate brain was an increase in the cerebrum size and a decrease in the size of the midbrain

G. Plant evolution
  1. In the life cycle of the most primitive plants, the haploid stages are dominant while the dominant stage of the more advanced plants is diploid
  2. The evolution of plants shows a tendency towards reduction of the gametophyte and an increase in the sporophyte generation
  3. The angiosperms are the most successful land plants because they have evolved the most efficient adaptations for living and reproducing on land

H. Animal evolution
  1. Characteristics such as type of symmetry, segmentation, embryonic development, and larval forms are used to establish phylogenetic relationships among the animals
  2. The chordates and echinoderms are believed to have evolved from a common ancestor
  3. The vertebrates are regarded as the most highly evolved representatives of the deuterostome line
  4. The arthropods are regarded as the most highly evolved representatives of the protostome line

I. Evolution
  1. Modern evolutionary theory is based on the idea that the genetically determined characteristics of organisms change with time, and this change is directed by natural selection
  2. Natural selection means nonrandom reproduction
  3. The raw material for natural selection is genetic variation caused by mutation
  4. Adaptations are genetically determined characteristics that improve an organisms chances of perpetuating the genes in future generations
  5. Modern classification systems attempt to discover the relationships among species and to reconstruct their evolutionary history

J. Ecology
  1. The niche is the functional role of and position of an organism in the ecosystem
  2. A species is always interacting in a variety of ways with other species in its community
  3. The movement of energy and materials in the community ties it together and binds it with the physical environment as one system
  4. Energy is always reduced in an ecosystem as it is passed along through food chains in a noncyclic flow

K. Behavior
  1. All living things appear to have an internal sense of time - a biological clock
  2. All forms of learning and behavior patterns depend on adequate motivation in animals
  3. Behavior is adaptive and natural selection brings about an increase in well-adapted and a decrease in poorly adapted behavior patterns

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

BIOLOGY 454

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Biology 454
Average and Above
GRADES ELEVEN AND/OR TWELVE

This course is for those students interested in a second year of biology at a more sophisticated level who are not able or willing to do advanced placement level work. Many, but not all of the topics covered in the advanced placement course are covered in Biology 454.

I. Instructional Objectives

- A. The student should develop an understanding of the unity and diversity in living things at the molecular, cellular, organismal, and populational level

- B. The student should develop an understanding of evolution as an explanation of unity and diversity

- C. The student should develop an understanding of homeostasis as a basic biological phenomenon and how homeostatic mechanisms involving feed-back control operate in plant and animal organ systems

- D. The student should develop an understanding of the means by which biological information is collected, how it is interpreted, and how one formulates hypotheses from available data and makes further predictions

- E. The student should become familiar with the evidence that supports the major concepts in biology

- F. The student should develop an understanding of science as a human endeavor with social consequences

II. Content Outline

- A. Basic chemistry
    1. Atoms and isotopes
    2. Chemical bonds
    3. Chemical reactions and equilibria
    4. Energetics: free energy change and entropy
    5. Chemical composition of organisms
        - a. Principal elements in organisms
        - b. Properties of water
        - c. Chemical structure of important organic substances
            - 1) Carbohydrates
            - 2) Lipids
            - 3) Proteins
            - 4) Organic acids
            - 5) Nucleic acids

- B. Cells
    1. Historical development of the cell concept

2. Cell ultrastructure
    a. Role and limitations of biochemistry, centrifugation, and microscopy (light and electron) in inderstanding cells
    b. Structure and function of cell organelles
    c. Cell (plasma) membrane and its properties
    d. Comparison of prokaryotic and eukaryotic cells

C. Enzymes
  1. Enzyme-substance complex
  2. Role of coenzymes, inorganic cofactors, and prosthetic groups
  3. Factors affecting the rate and/or direction of enzyme reactions

D. Energy transformations
  1. Aerobic and anaerobic respiration
    a. Chemical structure and function of ATP
    b. Pathways of aerobic respiration
      1) Krebs cycle
      2) Cytochrome (electron) transport system
    c. Pathways of anaerobic respiration
      1) Glycolysis
      2) Fernmentation
    d. Sites of respiratory enzymes
    e. Factors affecting the rate of respiration
  2. Photosynthesis
    a. Historical developments
    b. Factors affecting the rate of photosynthesis
    c. Role of pigments and plastids
    d. Absorption spectra and action spectra
    e. Nature and interrelation of light and dark reactions
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E. Cell division
  1. Structure of chromosomes
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F. Chemical nature of the gene
  1. Watson-Crick model of nucleic acids
  2. Self-copying of DNA molecule
  3. Genetic code and chemical nature of mutation
  4. Control of protein synthesis: transcription and translation
  5. Gene regulation: structural and regulatory genes
  6. Principles of transformation and transduction

G. The origin of life
  1. Modern theories
  2. Experimental evidence

H. Plant reproduction and development
  1. Growth and development including hormonal control: auxins, kinins, gibberellins, and other phytohormones
  2. Tropism and photoperiodicity

Biology 454
GRADES ELEVEN AND/OR TWELVE

I. Structure and function in animals with emphasis on vertebrates
   1. Major systems: digestive, respiratory, circulatory, and excretory
   2. Homeostatic mechanisms
      a. Nueral controls in homeostasis
      b. Hormonal controls in homeostasis
   3. Hormones in reproduction
      a. Hormonal control of gamete production
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   5. Extraembryonic membranes of vertebrates
   6. Formation and function of the mammalian placenta
   7. Pattern of circulation in a human embryo and the changes occurring at birth

K. Principles of heredity
   1. History of early experiments in heredity
   2. Mendelian inheritance: dominance, segregation, independent assortment
   3. Probability
   4. Chromosomal basis of inheritance
      a. Sex determination
      b. Chromosomal abnormalities: Klinefelter's syndrome, Down's syndrome, Turner's syndrome, and others
   5. Linkage
   6. Sex-linked, sex-influenced, and sex-limited inheritance
   7. Polygenic inheritance: height and skin color
   8. Multiple alleles, human blood groups

L. Principles of evolution
   1. History of evolutionary concepts: Lamarckian and Darwinian theories
   2. Modern concept of natural selection - differential reproduction
      Mutation

M. Implications of biomedical progress
   1. Control of human reproduction
   2. Genetic engineering and genetic counseling

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2. When gametes are produced the chromosome number is reduced by half and when fertilization occurs the normal diploid number is restored
3. Sexual reproduction increases variation in the population by making possible genetic recombination
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6. Genes do not alter one another but remain distinct and segregate unchanged when meiosis occurs
7. The inheritance patterns for characteristics controlled by genes on the X- chromosome are different from those controlled by autosomal genes

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1. DNA is the genetic material and can replicate itself. It controls the functioning of all cells by directing protein synthesis
2. The sequence of bases in DNA determines the amino acid sequence in proteins. This base sequence is a code in the form of 3 nucleotides for each mino acid
3. The code is degenerate, non-overlapping and universal
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2. Heterotrophs depend on nutrients synthesized by autotrophs and must digest these nutrients into smaller molecules before their cells can absorb them
3. Extracellular digestion is the general rule in multicellular annuals
4. Gas exchange between a living cell and its environment always takes place by diffusion across thin, moist cell membranes
5. Most organisms require a transport system to rapidly distribute gases and other substances from the surface to the internal cells or from one part of an organism to another
6. Organisms have various mechanisms for maintaining a relatively constant internal environment despite changes in the extreme environment
7. Plant cells can withstand greater changes in their extra cellular fluid than animal cells
8. Animals utilize various mechanisms for eliminating metabolic wastes and regulating salt and water balance
9. Hormone control mechanisms coordinate many of the functions of plants and animals including growth and development

F. Evolution
   1. Modern evolutionary theory is based on the idea that the genetically determined characteristics of organisms change with time, and this change is directed by natural selection
   2. Natural selection means nonrandom reproduction
   3. The raw material for natural selection is genetic variation caused by mutation
   4. Adaptations are genetically determined characteristics that improve an organisms chances of perpetuating the genes in future generations
   5. Modern classification systems attempt to discover the relationships among species and to reconstruct their evolutionary history

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

ASTRONOMY 464

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Astronomy 464
Average and Above
GRADES ELEVEN AND/OR TWELVE

This elective course offers one credit toward graduation. Upon successful completion of the course, the student will demonstrate an understanding of the following:

I. Instructional Objectives

A. Limitations of earth as an observational base

B. Identification of selected stars and constellations

C. How the motions of sun, moon, and planets gave rise to the theories of the ancient Greeks, Ptolemy, and Copernicus

D. How early humans thought of the universe

E. Our modern viewpoint of solar system members as discovered by modern spacecraft

F. History of modern spacecraft

G. The sun as an average star

H. The nature of light

I. Stellar spectra

J. The nature of stellar spectra

K. Stellar distances

L. Stellar evolution

M. Galaxy types

N. Cosmological models

II. Content Outline

A. Earth
  1. Physical characteristics
  2. Limitations of earth as an observational base
    a. Atmosphere
    b. Rotation
    c. Revolution
    d. People's influence

B. Observations in the planetarium
   1. Constellations
      a. North circumpolar
      b. Four seasonal groups
      c. Zodiac
   2. Special features
   3. Brightest stars
   4. Moving bodies
      a. Sun
      b. Moon
      c. Five naked eye planets
         1) Inferior
         2) Superior
      d. Special configurations

C. Orbits of planets
   1. Drawing apparent orbit of sun
   2. Drawing earth's orbit from sun's apparent orbit
   3. Drawing orbit of Mercury (inferior)
   4. Drawing orbit of Mars (superior)
   5. Drawing orbit of Venus (inferior)

D. Use of star maps and graphic ephemeris
   1. Practice with celestial sphere model
   2. Plotting planet positions on students' birthdays
   3. Using graphic ephemeris

E. Astronomy of ancient Greeks
   1. Pre-Greek astronomy
      a. Mesopotamians
      b. Babylonians
      c. Sumerians
   2. Greek astronomy
      a. Cosmology of ancient Greeks
      b. Claudius Ptolemy
         1) Almagest
         2) System of Ptolemy

F. Historical development of Heliocentric system
   1. Copernicus
   2. Tycho
   3. Kepler
   4. Galileo

G. Isaac Newton
   1. Influence on science
   2. Influence on astronomy

H. Albert Einstein
   1. Influence on science
   2. Influence on astronomy

Astronomy 464
GRADES ELEVEN AND/OR TWELVE

I. The moon
   1. Surface features
   2. Phases
   3. Eclipses

J. Overview of the solar system

K. Mercury
   1. Telescopic observations
   2. Mariner observations

L. Venus
   1. Telescopic observations
   2. Venus viewed by United States and Russian spacecraft

M. Earth

N. Mars
   1. Telescopic observations
   2. Mars viewed by various spacecraft

O. Jupiter
   1. Telescopic observations
   2. Jupiter visited by spacecraft

P. Saturn
   1. Telescopic observations
   2. Saturn visited by spacecraft

Q. Uranus, Neptune, Pluto

R. Space travel
   1. Early rocketry
   2. Early space program
   3. Modern space program
   4. Future prospects

S. Nature of light and spectroscopy
   1. Apparent stellar magnitudes
   2. Colors of stars
   3. Absolute magnitudes of stars
   4. Spectral sequence
   5. Analysis of line spectra
   6. What is learned from stellar spectra
      a. Temperature
      b. Pressure
      c. Relative abundance of elements
      d. Radial velocity
      e. Rotation
      f. Turbulence
      g. Magnetic fields

- T. Hetzsprung-Russell diagram
  - 1. Brightest stars vs. nearest stars
  - 2. Main sequence
  - 3. Spectrospcopic parallaxes
  - 4. Giant stars
  - 5. Dwarf stars

- U. Unusual stars
  - 1. Stars that vary in light intensity
  - 2. Pulsating stars
  - 3. Eruptive variables
  - 4. Stars with extended atmospheres
  - 5. X-ray stars
  - 6. Pulsars
  - 7. Black holes

- V. Stellar distances
  - 1. Triangulation
  - 2. H-R diagram
  - 3. Astronomical unit
  - 4. Cepheid variables
  - 5. Parsecs

- W. Stellar evolution
  - 1. Beginnings of stars
  - 2. Main sequence
  - 3. Giant stars
  - 4. Main sequence crossing
  - 5. Dwarf stars
  - 6. Black holes

- X. Galaxies
  - 1. Types
  - 2. Evolution theories
  - 3. Milky Way
  - 4. Local group

- Y. Cosmology
  - 1. Big bang theory
  - 2. Pulsating theory
  - 3. Steady state theory

III. Concepts to be Taught

- A. The earth imposes severe limitations on our perception of the universe

- B. If one recognizes the brightest stars and the unchanging constellation patterns, it is possible to identify and follow the motions of the planets

- C. The motions of the sun, moon, and planets confused humans for thousands of years giving rise to many models and theories of the universe

D. One of the most dramatic changes in people's view of themselves and the universe resulted from the introduction of the Copernican theory and the subsequent work of Kepler and Newton

E. The moon has a tremendous influence on a major portion of life on earth

F. People have shown that it is possible to go into space and live and work there. This will probably give rise to future space habitats

G. Our solar system is more complex than people used to imagine

H. Studying other members of our solar system will help us understand the past and future of the earth

I. Our sun is an average star

J. Stars evolve from gas clouds

K. Stars are the only places in space where there is enough energy to have produced thermonuclear reactions to create heavy elements out of the hydrogen from which the universe probably began

L. All stars do not evolve to the same end. How they end their "lives" is determined by their mass

M. Under the extreme conditions found in massive stars, Newton's laws do not hold up. Einstein produced another revolution in people's thinking by introducting the theory of relativity early in this century

N. In the concept of black holes, Einstein's theory had to be "adjusted"

O. By placing telescopes into orbit above the earth's atmosphere, people are receiving tremendous amounts of data in all wavelengths of the electromagnetic spectrum. This influx of data as analyzed by computers is changing our understanding of the universe

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

PHASE SCIENCE 45501 and 45502

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Phase Science 45501 and 45502
Not Grouped
GRADES ELEVEN AND/OR TWELVE

Two modules are available to students, 45501 and 45502. Module I - 45501, consists of the following nine-week courses of study: Backpacking Biology, Greenhouse, Elementary Chemistry, and Environmental Pollution and Ecology. Module II - 45502, consists of Backpacking Biology, Greenhouse, and eighteen-week (one semester) Environmental Pollution and Ecology course. Either module I or II will result in one year of credit toward graduation. The courses are designed for the nonscience, noncollege preparatory student of average ability.

Elementary Chemistry
Phase Elective

I. Instructional Objectives

   A. State the three phases of matter

   B. Compare and contrast solids, liquids, and gases

   C. Give examples of the physical properties of matter

   D. Define chemistry

   E. List several branches of chemistry

   F. List and identify components of the Scienctific Method of Inquiry

   G. Differentiate between mass and weight

   H. Use a meter stick and convert from kilometers to meters or centimeters to millimeters

   I. Use a graduated cylinder accurately and appropriately

   J. Use a single-pan, triple beam balance accurately

   K. Differentiate between density and specific gravity

   L. Define the kinetic molecular theory of matter

   M. Compare and contrast potential and kinetic energy

   N. Compare and contrast the Fahrenheit, Celsius, and Kelvin scales

   O. Define a calorie as a unit of heat quantity

   P. Describe the properties

Q. Differentiate between metals and nonmetals

R. Distinguish between physical and chemical changes

S. Give examples of elements, compounds, and mixtures

T. Identify chemical symbols

U. Write chemical equations for simple reactions

V. Observe changes in a simple plating solution reaction with a metal

W. Identify the element formed by a process of elimination after subjecting the unknown element to certain simple qualitative tests

X. Observe and measure exothermic reactions

Y. Observe, compare, and contrast various solutions with a metal foil

Z. Find the volume of an irregularly shaped object by the displacement method

AA. Find the density of different unknown metals

BB. Observe and measure the effect of sodium chloride on the freezing point of water

CC. Observe and measure the melting points of different substances

DD. Observe and measure the solubility of different salts

EE. Quantify a chemical reaction

FF. Observe various qualitative reactions on various salt solutions

GG. Setup a simple filtration apparatus

HH. Setup a simple evaporation appratus

II. Content Outline

A. Definition of chemistry

B. History of chemistry

C. Branches of chemistry

D. The Scientific Method of Inquiry

E. Mass vs. weight

F. The metric system of measurement

G. Density

H. Specific gravity

I. Phases of matter

J. Diffusion

K. The kinetic molecular theory of matter

L. Potential vs. kinetic energy

M. Measurement of heat

N. Properties of matter

O. Metals vs. nonmetals

P. Elements

Q. Compounds

R. Mixtures

S. Physical change vs. chemical change

T. Chemical symbols

U. Chemical equations

III. Concepts to be Taught

A. The evolution of chemistry
   1. Chemistry evolved as a result of people trying to comprehend and to organize a world of constantly changing matter
   2. The process began very slowly over many hundreds of years and gradually increased as various key points were found in this immensely large jigsaw puzzle
   3. At first, the process was just a matter of trial and error, but it eventually evolved into some very sophisticated and complex tools
   4. These tools allowed people to organize, through comparison and contrast by observation and measurement, the myriad of formerly vague and uncertain bits of information into a knowable body of knowledge that could be stored and catalogued for future generations

B. The gathering of facts
   1. Matter needed to be measured by weight, length, and volume
   2. Standards became necessary in order to facilitate the exchange of information
   3. More complex relationships were discovered as a result of simple measurements such as density and specific gravity

C. The classification of matter
   1. All mater can be classified into three phases: solids, liquids, or gases
   2. All matter is in a constant state of motion
   3. The motion of molecules of matter can be measured not only by its speed, but also the quantity of energy it contains as defined by its mass and volume
   4. Matter can be classified as metals or nonmetals depending on its physical properties

D. Further subdivisions of matter
   1. Matter can also be an element, compound, or a mixture
   2. There are many different kinds of elements in the universe
   3. These elements can be represented by symbols
   4. These elements can undergo physical and chemical change
   5. These chemical changes can be expressed as chemical equations

Backpacking Biology
Phase Elective

I. Instructional Objectives

A. List forest facts as they relate to conservation

B. Distinguish the environmental concerns of the backpacker as they differentiate from everyday environmental concerns

C. Physically improve the environment on the school grounds

D. Memorize the names of various flora indigenous to the North Eastern part of the United States

E. Develop an understanding of the purpose of plants in the environment

F. Peacefully coexist with bears when backpacking in areas where bears are found

G. Identify various wildlife by memorizing names

H. Determine the habitat of various fauna and why it needs a certain habitat

I. Identify certain insects and how to avoid problems with them

J. Purify drinking water found in wilderness areas

K. Select the proper equipment for use in backpacking experiences

L. Plan balanced meals being concerned about calories and nutritional complement

M. Avoid physiological situations that could cause health problems, discomfort or death while backpacking

N. Protect themselves from harm during thunderstorms

O. Identify the constellations that are a part of the backpackers' sky

II. Content Outline

A. Wilderness conservation
  1. Forest fires
  2. Forest and wilderness resources
  3. Overuse of wilderness areas
  4. Definition: what is true wilderness?
  5. Reducing environmental impact while backpacking
  6. The beavers contribution to wilderness conservation
  7. Work at the nature site

B. Plants (flora)
  1. Wild edibles
  2. Poisonous plants

3. Lichens
4. Plant community (succession)
5. Tree identification
6. Mushrooms
7. Wildflowers

C. Wildlife (fauna)
1. Bears
2. Timber wolves
3. Snakes
4. Amphibians
    a. Frogs
    b. Toads
    c. Salamanders
5. Turtles
6. Endangered species
7. Selected mammals
8. Fish and fishing
9. Birds

D. Field trip I
1. Review of plants in the field
2. Review of animals in the field

E. Bugs
1. Mosquitoes
2. Black flies
3. Biting midgets
4. Chiggers
5. Ticks
6. Spiders
7. Scorpions
8. Blister beetles
9. Ants
10. Other pests
11. Butterflies and moths

F. Drinking water
1. Amounts needed
2. Contamination
3. Methods of water purification
4. Parasitic contamination

G. Backpacking equipment
1. How to select equipment
2. Equipment checklist

H. Backpacking nutrition
1. Basic nutrition
2. Energy requirements
3. When to eat
4. How much to eat
5. Menu planning

Backpacking Biology

I. Physiological problems
1. Fatigue - exhaustion
2. Hypothermis and alcohol
3. Foot problems
4. Contact lens care
5. Overheating

J. Thunderstorms

K. The bakcpackers' sky

L. The one day backpack trip (field trip II)

M. Optional: 2 days, 3 nights - backpack trip

III. Concepts to be Taught

A. Wilderness conservation will be taught in such a manner that the students will comprehend the wilderness invironment as a place to be visited and loved without leaving traces of people's presence

B. Wild edible plants can be used to supplement the backpackers' diet, however, they should be used sparingly if endangered

C. Some plants are poisonous and should be avoided

D. Plants should be recognized as a community of living things

E. The use of a dicotomous key is an important tool of the bakcpackers

F. An enjoyable aspect of backpacking is the identification or recognition of the plants in the environment

G. It is possible to peacefully coexist with bears (most of the time) in their environment

H. To make the students aware of the fact that the timber wolf has suffered unjustly in the hands of people

I. Snakes have a very important ecological function and thus should not be feared or destroyed

J. As a society, we are dependent upon all wildlife and their interrelationships for our existence

K. Many animals are endangered because of people and, therefore, need to be preserved

L. People can avoid having bugs ruin their stay in the environment by being more aware of the characteristics bugs possess and how to avoid bugs

Backpacking Biology

M. Clean, disease free water is an important commodity

N. The proper equipment is necessary for an enjoyable backpacking trip; know how to select it

O. Proper nutrition which backpacking is vital

P. Physiological problems can be avoided through proper foreknowledge

Q. Thunderstorms can be killers

R. The stars of the heavens are one of the backpackers' most awesome rewards

Greenhouse
Phase Elective

I. Instructional Objectives

A. Identify forty plants by their common name

B. Work independently in the greenhouse providing maintenance and care for the plants

C. Propagate plants by cuttings

D. Propagate plants from seeds

E. Propagate plants using other technique (eg. root divisions and air layerings)

F. Transplant seedlings, as well as plants in other stages of development

G. Propagate ferns from spores

H. Differentiate between sexual and asexual reproduction in plants

I. Keep plants alive in their homes

J. Build a terrarium

K. Develop the proper technique for watering plants

L. Develop the proper techniques for fertilizing plants

M. Build a dish garden

N. Identify the structure of a plant

O. Macrame plant hangers

P. Identify bug and pest problems, as well as know how to control them

II. Content Outline

A. Plant identification
  1. Five plants per week
  2. Common names only

B. Introduction
  1. Rules and regulations
  2. How the greenhouse operates
  3. Greenhouse management
  4. Virus disease and tobacco

C. Fun with plants
  1. Visit plant places
  2. Buying plants
  3. Taking plants home

D. Propagating plants from cutting

E. Starting plants from seed

F. Plant propagation
  1. Root division
  2. Air layering
  3. Leaf bud cuttings
  4. From dustlike seed or spores

G. Difference between sexual and asexual reproduction

H. Rules for success with your plants

I. Construct a terrarium

J. How to water plants
  1. Damping off
  2. Mildew

K. How to fertilize plants

L. Build a dish garden

M. Plant structure
  1. Notes
  2. Flower disection lab
  3. Seed disection lab

N. The Aloe Vera plant

O. Macrame a plant hanger

P. Bug problems and how to deal with them
  1. Bug juice method of pest control
  2. Alternative methods of control
  3. Color control for white fly
  4. Battling bugs with biology
  5. Insecticide and pest control

Q. Propagate a:
  1. Pineapple
  2. Citrus
  3. Avocado

III. Concepts to be Taught

A. It is important for plants to be identified so communication about them can occur. Although the use of common names is not universally accepted, it offers a quick and easy way to learn means of identification

B. The students must learn that foolishness in the greenhouse can be dangerous. Therefore, rules exist for their protection

C. The management of a greenhouse requires a tremendous amount of work and can occur. Although the use of common names is not universally accepted, it offers a quick and easy way to learn means of identification

D. The study of plants will be approached with the idea that plants are fun with emphasis on the fact that students will come to love and appreciate them also

E. The propagation of plants is obviously a most important idea for perpetuation of the various species. Therefore, an understanding of the various methods becomes most necessary

F. Sexual and asexual methods of reproduction are important considerations for the plant grower

G. Once plants have been established it becomes important to keep them "happy" and healthy. Understanding how to water, fertilize, and "how to talk to your plants" will enable one to be successful

H. Construction of dish gardens and terrariums, as well as macrameing plant holders, allows one to employ the knowledge gained in the study of the plants while allowing for the enjoyment of the plants in creative display

I. Plants have a specific structure which is important for their growth and to the understanding of how plants survive and thrive

J. The Aloe Vera plant is known as a magical plant because of the healing properties it possesses

K. Bugs and other pests can cause serious problems for plants. Knowledge of how to control these problems through the safe use of insecticides or more importantly, with biological control, what is most necessary

L. Beautiful house plants can be propagated from overlooked items like pineapple tops, citrus seeds, and avocado seeds

Environmental Pollution and Ecology
(Eighteen-Week Unit)

I. Instructional Objectives

A. Define ecology as the study of the interrelationships between the biosphere and the physical environment

B. Define the biosphere as a whole organism made up of numerous interdependent ecosystems

C. Define an ecosystem as a smaller complex whole than the biosphere but capable of maintaining a viable interdependent system of various unique plant and animal components

D. Compare and contrast the American Indians's environmental ethic with that of contemporary people

E. Compare and contrast the environmental ethic of the early pioneer and early industrialist with that of today's industrialist, corporate farmer, and developer

F. List several historical precendents involving ecological disruptions

G. List five endangered animals and five endangered plants in the United States

H. List three causes of endangered plants or animals

I. Diagram a food cycle which includes: producers, primary consumers, secondary consumers, and tertiary consumers

J. Construct a simple exosystem that lives for three months or longer

K. Explain how energy is transferred within an ecosystem

L. Explain the mechanism of natural succession

M. Explain the importance of decomposers in a food cycle

N. Explain what effect desertification will have on food production

O. List two natural events that cause agricultural disruptions

P. List two people-made activities that cause agricultural disruptions

Q. List two things that increase a soil's fertility

R. List two examples of people's failure to understand natural ecosystems which resulted in serious effects on human life

S. Identify five hazardous substances that people have introduced into his/her environment that pose a serious threat to health and well-being

T. Identify the traditional method of disposal of hazardous wastes

Environmental Pollution and Ecology

U. Describe a shortcoming of traditional hazardous waste disposal

V. Identify the location of at least one catastrophic event resulting from transportation of hazardous substances

W. Identify the location of at least one catastrophic event resulting from the disposal of hazardous wastes

X. Explain how people have traditionally dealt with insect pests

Y. Describe how pesticidal use has compounded the pest problem

Z. Identify three harmful pesticides that were innocently used

AA. Identify two natural pesticides

BB. Define chlorinated hydrocarbons

CC. Define toxicity

DD. Identify three arguments against the use of chlorinated hydrocarbons

EE. Identify three factors which contribute to insect resistance to pesticides

FF. List four alternatives to pesticide use

GG. List four advantages of pesticidal alternatives

HH. Identify traditional sources of energy

II. Describe three alternative sources of energy

JJ. List a disadvantage of fossil fuel use

KK. List a disadvantage of nuclear energy plants used for electric power generation

LL. List the effect of radioactivity on life

MM. Diagram the basic components of a nuclear power plant

NN. List two factors that need to be considered for radioactive waste disposal

OO. Define the term half-time

PP. Identify the level of radiation that is hazardous to health

QQ. Define geothermal energy

RR. Diagram a simple wind power generator

SS. Identify two alternative fuels

TT. Describe the principle of fusion power generation

UU. Identify two alternative sources of energy for transportation

VV. Diagram a simple solar energy heating system

WW. Identify two unusual sources of fuel generation

XX. Distinguish between people-made and natural air pollution sources

YY. Identify the quantity of a specific pollutant that is hazardous to human health

ZZ. Identify what pollutants become hazardous to health when exposure occurs over a long period of time even though amounts may appear innocuous

a. Identify the range of particle sizes which can circumvent the body's defenses

b. List three common air pollutants resulting from the oxidation of fossil fuel

c. List three common air pollutants not resulting from the oxidation of fossil fuel

d. Identify three significant effects of air pollution on the earth's environment

e. Identify three diseases that show a casual relationship to air pollution and human illness

f. Diagram a simple air pollution control that could reduce auto emmisions

g. Diagram a simple air pollution control that has industrial applications

h. Identify two unique properties of water

i. Explain how each of these properties are beneficial to plant and animal life

j. Explain how each of these properties are detrimental to plants and animals when the concentrations of the pollutants reach certain levels

k. List three impurities found in natural waters

l. Identify three substances that would be harmful in drinking water

m. Identify two substances in water that could be hazardous if it comes in contact with animal life

o. Identify the quality of water needed in laboratory use

p. Identify three common sources of water pollution

q. Define the term biodegradable

r. Define biochemical oxygen demand

s. Explain the effect of pH on life forms

t. Diagram a common method of water purification before and after human consumption

u. Define thermal pollution

v. Identify two large industrial sources of thermal pollution

w. Identify one method of treating thermal pollution

x. List ten sources of solid wastes

y. Explain one disadvantage of the most common method of solid waste disposal

z. List two alternative methods of solid waste disposal

aa. Explain one advantage of at least one of these alternative methods of waste disposal

bb. Define the terms: growth rate and rate of change

cc. Discuss some uses of growth predictions

dd. Explain Thomas Malthus' theory of growth

ee. Define a sigmoid curve

ff. Define the terms: demography, vital event, and vital rate

gg. Contrast fertility and fecundity

hh. Explain the use of age-sex distribution curves as predictors of future populations

ii. List some possible consequences of an unchecked growth curve

jj. Explain how finite supplies will be consumed by unlimited growth

kk. Define the terms: subsonic, supersonic, amplitude, frequency, and wavelength

ll. Explain the decibel scale

mm. Identify the range of sound waves that are hazardous to human health

nn. List one effect of noise pollution other than loss of hearing

oo. Identify two methods of eliminating noise pollution pp. Identify one unique noise pollution problem occuring now

II. Content Outline

A. Ecology and environmental ethics
   1. Definition of ecology
      a. Ecology
      b. Ecosystem
   2. Homeostatic stability
      a. Homeostasis
      b. Buffering
      c. Ecosystem homeostasis
   3. Food cycles
      a. Photosynthesis
      b. Herbivores
      c. Carnivores
      d. Omnivores
      e. Land-based food cycles
      f. Aquatic-based food cycles
   4. The disruption and recovery of ecosystems
      a. Ecological niche
      b. Symbiosis
   5. Natural succession
      a. Natural succession
      b. Climax forests
   6. The role of people
      a. Benefits
      b. Harmful practices
      c. Endangered animals
      d. Endangered plants
      e. Values of modern people
      f. Values of the American Indian

B. Soil and agricultural practices
   1. Agricultural ecosystems
      Brief history of farming
   2. The techniques of agriculture
      a. Large animal consumers are physically separated from crops
      b. Only selected crops are cultivated
      c. Refertilization
      d. Irrigation
   3. Agricultural disruptions
      a. Desertification
      b. Over-grazing
      c. Dust mulching
      d. Over irrigation
      e. Damming
   4. Land and people
      Understanding past failures

C. Pesticides
   1. Competition for food between insects and people

- Natural pesticides
  - 1) Pyrethrum
  - 2) Rotenone

2. Chlorinated hydrocarbons
   - a. Universal poisons
     - 1) DDT
     - 2) Toxaphene
     - 3) Mutations
     - 4) Insect pests are smaller and reproduce more frequently than predators
     - 5) Predators eat a diet richer in pesticides
     - 6) Fewer predators than herbivores
   - b. Degrade slowly
   - c. Fat-soluble
     - 1) Solution
     - 2) Insoluble
3. Pest control alternatives
   - a. Short-lived pesticides
   - b. Natural insect enemies
   - c. Sterilization techniques
   - d. Use of insect hormones
   - e. Sex attractants
   - f. Resistant strains of crops
   - g. Cultural controls

D. Hazardous wastes

1. Sources of wastes
   - a. Industry
   - b. Military
   - c. Homeowner
2. Types of wates
   - a. Organic solids
   - b. Organic liquids
   - c. Inorganic solids
   - d. Inorganic liquids
   - e. Inorganic gases
3. Disposal and transportation of wastes
   - a. Landfills
   - b. Ocean dumping
   - c. Sewers
   - d. Atmospheric dispersal

E. Radioactive wastes

1. The dilemma
2. Atomic structure basics
   - a. Atomic number
   - b. Mass number
   - c. Atomic model
     - 1) Proton
     - 2) Neutron
     - 3) Electron
3. Radioactivity
   - a. Half-life
   - b. Background radiation

4. People-made radioactivity
   a. Nuclear chain reaction
      1) Chain lengthening
      2) Chain termination
      3) Chain branching
   b. Critical condition
5. Affects on the present and future life of increased radiation
6. Opposing views
7. Nuclear reactors and waste disposal
   a. Controlling the neutrons
      Moderator
   b. Removing unwanted heat
   c. Containing and disposing of radiation wastes
   d. Redundant safety devices
8. Radiation waste release and disposal problems

F. Energy alternatives
   1. Conservation
      a. Commitment to use less
      b. Recycling
   2. New discoveries
      a. Known reserves
      b. Reasonable expectations
   3. Alternate fuels
      Recyclable fuels
      1) Alcohol
      2) Nethane propagation
      3) Organic waste
      4) Wood
      5) Hydrogen
   4. Alternate sources of energy (natural)
      a. Solar
      b. Geothermal
      c. Tidal
      d. Wind
      e. Ocean currents
      f. Dams on rivers
   5. Alternate sources of energy (people-made)
      a. Hydrogen fusion
      b. Magnetism
      c. Ionic propulsion

G. Air pollution
   1. Definition of terms
   2. Measurement of gaseous particles
   3. Polluted vs. pure air
   4. Gaseous air pollutants
      a. Carbon oxides
      b. Hydrocarbons
      c. Sulfur compounds
      d. Nitrogen compounds
      e. Ozone and oxidants
      f. Hydrogen fluroides

5. Particulates
   a. Viable particles
   b. Nonviable particles
6. Effects of air pollution
   a. Atmosphere
   b. Vegetation
   c. Human health
   d. Animals
   e. Materials
7. Air pollution control
   a. By separation
   b. By conversion
8. Solutions and problems of control
   a. Solutions
      1) Change to another energy source
      2) Sulfur removal before burning
      3) Sulfur removal from exhaust gases
      4) More efficient fuel combustion
      5) Use less fuel
      6) Lower population growth
   b. Problems
      1) More central power plants
      2) Economic depression of oil industry
      3) Changes in automobile industry
      4) Changes in service changes
      5) Highway changes
      6) Taxes

H. Water pollution
1. Nature of water pollution
2. Water
3. Types of impurities
   a. Suspended particles
   b. Colloidal particles
   c. Dissolved matter
4. Composition of natural waters
5. Microorganisms
6. Nutrients and oxygen in water
   a. Aerobiosis
   b. Nitrification
   c. Anaerobiosis
   d. Fermentation
   e. Putrefaction
   f. Nonbiodegradable
   g. Biochemical oxygen demand
7. Detergents, algae, and eutrophication
8. Industrial wastes
9. Corrosiveness
10. Water purification
    Sanitary sewage

I. Solid wastes
1. Sources
2. Methods of disposal

        a. Land disposal
            Sanitary landfill
        b. Incineration
    3. Recycling
        a. Composting
        b. Rendering
        c. Destructive distillation
        d. Industrial salvaging

J. Growth of human population
    1. Introduction
    2. Growth curve predictions
        Thomas Robert Malthus
            1) Arithmetic rate
            2) Geometric rate
            3) Sigmoid curve
    3. Demography
        a. Vital event
        b. Vital rate
        c. Distribution
        d. Fertility
        e. Fecundity
        f. Demographic transition
    4. Future population sizes
        Birth cohort
    5. Ultimate human population

K. Noise pollution
    1. Sound
        a. Crests
        b. Troughs
        c. Wavelength
        d. Speed
        e. Frequency
        f. Elastic wave
        g. Subsonic
        h. Supersonic
    2. Loudness and decibel scale
    3. Noise effects
        a. Communication interference
        b. Loss of hearing
        c. Effects on health and behavior
    4. Noise control
        a. Reducing source
        b. Interrupting the path
        c. Protecting the receiver
    5. SST

III. Concepts to be Taught

A. Ecosystems
    1. Ecosystems are complex life systems that evolved over long periods of time

2. The healthiest ecosystems display a great diversity for life which allows it to withstand hostile natural changes over long periods of time
3. Today's highly industrial and technological society can alter natural ecosystems in short periods of time directly opposing the natural systems ability to maintain itself
4. People's future survival depends on living in harmony with support systems and preservation of future gene pools by the action or nonaction exhibited today

B. Agricultural practices
   1. Soil fertility and abundance evolved through slow natural processes
   2. Preservation and conservation will ensure fertile and abundant soil for future generations
   3. The quality and quantity of future foodstuffs depends on our foresight and consideration
   4. In the past, people's ignorance and blunders were forgiven by nature only because population and technology were small. Today, nature may not be as kind

C. Chemical misfortunes
   1. Chemicals devised to improve and enhance our synthetic worlds are being carelessly disposed of in a living dynamic world
   2. Chemicals harmful to a living chemistry have been locked-up in rock and mineral formations for millions of years and only released in minute amounts
   3. Massive release of these chemicals, haphazardly, may actually lessen the quality and quantity of life for many others
   4. When chemicals have the ability to effect mutagenic and teratogenic outcomes in new and unborn life forms, it has become imperative to contain these practices in a responsible and reasonable manner

D. Life support threats
   1. Physical and psychological factors need to be at reasonable levels for people to function to their fullest potential
   2. The composition of the atmosphere once was hostile to heteroptrophs on land based food webs
   3. The quality of air evolved over great lengths of time and cannot do so again naturally without some ill effects on animal life
   4. Sometimes the ill effects are swift and dramatic and at other times they are slow and subtle though just as injurious
   5. The quality of water evolved over great lengths of time
   6. The concentration of waste products being released into natural waterways is an archaic practice that can no longer be tolerated
   7. Solid wastes increase at a faster and faster rate as people's population increases
   8. Nature has always applied recycling practices toward all waste. People need to learn from nature how to deal with their nonbiodegradable wastes
   9. Quantity of populations are not automatically quality creations. Moral and ethical solutions need to be addressed for this perplexing and pressing dilemma

10. Natural predator-prey relationships have historically been checks and balances with regard to population growth of both plant and animal life
11. Normal predator-prey relationships are being disrupted by technology
12. Sound has been both beneficial and detrimental
13. Noise is increasing in volume and can have psychological effects on animal and plant life
14. When sounds cease being esthetically pleasing and soothing, then they no longer can be classified as sound but instead becomes noise

GRADED COURSE OF STUDY

INSTRUCTIONAL OBJECTIVES FOR SCIENCE

PHYSICS 421

COURSE OF STUDY

PROGRAM GOALS FOR SCIENCE

Physics 421
Advanced Placement
GRADE TWELVE

Advanced placement physics represents a college level introduction to physics for students who might major in the physical science or in engineering. Methods of calculus are used where appropriate in formulating physical principles and in applying them to physical problems

The course enables the student to take the AP exam in May and to receive college credit and/or placement

I. Instructional Objectives

- A. Read, understand, and interpret physical information - verbal, mathematical, and graphical
- B. Describe and explain the sequence of steps in the analysis of a particular physical phenomenon or problem
  1. Describe the idealized model to be used in the analysis, including simplifying assumptions where necessary
  2. State the principles or definitions that are applicable
  3. Specify relevant limitations on applications of these principles
  4. Carry out and describe the steps of the analysis, verbally or mathematically
  5. Interpret the results or conclusions including discussion of particular cases of special interest
- C. Use basic mathematical reasoning - arithmetic, algebraic, geometric, trigonometric, and calculus where appropriate in a physical situation or problem
- D. Perform experiments and interpret the results of observations, including making an assessment of experimental uncertainties

II. Content Outline

- A. Mechanics
  1. Measurement
     - Scaling
  2. Vectors
     - a. Addition
     - b. Scalar products
     - c. Vector products
  3. Kinematics
     - a. Constant acceleration
     - b. Variable acceleration
     - c. Projectile motion
     - d. Circular motion
  4. Particle dynamics
     - a. Newton's laws - vector form

   b. Friction
   c. Central forces
   d. Planetary motion
5. Work and energy
   a. Work done by a variable force
   b. Kinetic energy and the work-energy theorem
   c. Power
   d. Kinetic and potential energy
   e. Conservation of energy
   f. Relativistic mass-energy
6. Linear momentum and impulse
   a. Vector nature
   b. Center of mass motion
   c. Conservation during collision - one and two dimensions
7. Rotational mechanics
   a. Torque acting on a particle
   b. Angular momentum of a particle
   c. Kinetic energy and inertia of a rotating system
   d. Combined translation and rotation of a rigid body
   e. Conservation of angular momentum - the top
8. Equilibrium of rigid bodies
   a. Translational
   b. Rotational
9. Oscillations
   a. Simple harmonic motion
   b. Energy considerations in S.H.M.
   c. Uniform circular motion related to S.H.M.
   d. Damped harmonic motion
10. Gravitation
   a. The universal law of gravitation for point masses
   b. The gravitational field
   c. Gravitational potential energy
   d. Planets and satellites
   e. The principle of equivalence

B. Electromagnetism
1. Electrostatics
   a. Charge
   b. Coulomb's law
   c. Quantization - Millikan experiment
   d. Conservation
2. The electric field, $\vec{E}$
   a. Definition of electric field strength $\vec{E}$
   b. Lines of force
   c. Behavior of a charge in an $\vec{E}$ - field
   d. Gauss's law
   e. Applications
3. Electric potential, V
   a. Definition and calculation for point charge
   b. A group of point charges
   c. Gradient of potential

d. Electric potential energy
e. Energy density
f. Capacitance
g. Capacitors with dielectrics
h. Rutherford scattering

4. D C circuitry
   a. Current density
   b. Resistance
   c. Ohm's law, applications
   d. Energy transfer in a circuit
   e. Multiloop circuits
   f. R C circuits
5. The magnetic field, $\vec{B}$
   a. Definition of $\vec{B}$
   b. Behavior of a moving charge in $\vec{B}$
   c. Behavior of a current in $\vec{B}$
   d. Circulating charges, the cyclotron and mass spectrograph
   e. J. J. Thompson's experiment e/m
   f. Ampere's law
   g. The law of Biot-Savart
6. Electromagnetic induction
   a. Faraday's law
   b. Lenz's law
   c. Relativity
   d. Inductance
   e. L R circuits
   f. Energy, energy density, and the magnetic field
   g. Analogies between $\vec{E}$ and $\vec{B}$
7. Magnetic properties of matter

III. Concepts to be Taught

A. Motion in one dimension

1. The general relationships among position, velocity and acceleration for the motion of a particle along a straight line so that students can:
   a. Given a graph of position as a function of time, identify or sketch a graph of velocity as a function of time
   b. Given a graph of velocity as a function of time, identify or sketch graphs of position and acceleration as functions of time
   c. Given x(t) for position as a function of time, determine velocity and acceleration as functions of time, and find when these quantities achieve their maximum and minimum values
   d. Given an expression a(t) for acceleration as a function of time, plus initial conditions, determine velocity and position as functions of time, and find where these quantities achieve their maximum and minimum values
2. The special case of motion with constant acceleration so that students can:
   a. Write down expressions for velocity and position as functions of time and identify or sketch graphs of these quantities

    b. Use the equations $v = v_0 + at$, $x = x_0 + v_0t + at^2/2$, and $v^2 = v_0^2 = 2a\ (x - x_0)$ to solve problems involving one-dimensional motion with constant acceleration, including ones which involve two accelerating bodies
  3. How to deal with situations in which acceleration is a specified function of velocity and time so that students can write down an appropriate differential equation $dv/dt = f(v)g(t)$ and solve it for $v(t)$, incorporating correctly a given initial value of v

B. Motion in a plane
  1. How to deal with displacement vectors and velocity vectors so that students can:
    a. Relate velocity, displacement, and time for motion with constant velocity
    b. Resolve a vector into components along two specified mutually perpendicular axes
    c. Add vectors in order to find the net displacement of a particle which undergoes successive straight-line displacements
    d. Subtract displacement vectors in order to find the location of one particle relative to another
  2. The general motion of a particle in two dimensions so that, given functions $x(t)$ and $y(t)$ which describe this motion, students can determine the components, magnitude, and direction of the particle's velocity and acceleration as functions of time
  3. The motion of projectiles in a uniform gravitational field so that students can:
    a. Write down expressions for the horizontal and vertical components of velocity and position as functions of time
    b. Use these expressions in analyzing the motion of a projectile which is projected above level ground with a specified initial velocity
  4. The uniform circular motion of a particle so that students can:
    a. Relate the radius of the circle, the speed of the particle and the rate of revolution
    b. Determine the magnitude and direction of the particle's velocity and acceleration

C. Dynamics of a single body
  1. The relation between the force which acts on a body and the resulting change in the body's velocity so that students can:
    a. For a body moving in one dimension, calculate the velocity change which results when a force $F(t)$ acts over a specified time interval
    b. For a body moving in a plane whose velocity vector undergoes a specified change over a specified time interval, determine the average force F which acted on the body
  2. How Newton's second law $\vec{F}_{net} = \overrightarrow{ma}$ applies to a body subject to forces such as gravity, the pull of strings, or contact forces, so that students can:

   - a. Draw a well-labeled diagram showing all real forces which act on the body
   - b. Write down the vector equation which results from applying Newton's second law to the body, and take components of this equation along appropriate axes
3. To analyze situations in which a particle is in static equilibrium under the influence of several forces
4. To analyze situations in which a body moves with specified acceleration in the earth's gravitational field so that students can determine the magnitude and direction of unknown forces in situations such as the following:
   - a. Motion up or down with constant acceleration (in an elevator, for example)
   - b. Motion in a horizontal circle (mass on a rotating merry-go-round, or a car rounding a banked curve)
   - c. Motion in a verticle circle (mass swinging on the end of a string, cart rolling down a curved track, or a rider on a ferris wheel)
5. The significance of the coefficient of friction so that students can:
   - a. Write down the relation between the normal and frictional forces on a surface
   - b. Analyze situations in which a body slides down a rough inclined plane or is pulled or pushed across a rough surface
   - c. Analyze static situations involving friction to determine under what circumstances a body will start to slip
6. The effect of fluid friction on the motion of a body so that students can:
   - a. Find the terminal velocity of a body moving vertically through a fluid that exerts a retarding force proportional to velocity
   - b. Describe qualitatively, with the aid of graphs, the acceleration, velocity, and displacement of such a particle when it is released from rest or projected vertically with specified initial velocity

D. Systems of two or more bodies
1. Newton's third law so that, for a given force, students can identify the body on which the reaction force acts and state the magnitude and direction of this reaction force
2. To apply Newton's third law in analyzing the force of contact between two bodies which accelerate together along a horizontal or vertical line, or between two surfaces which slide across one another
3. That the tension is constant in a light string which passes over a massless pulley and students should be able to use this fact in analyzing the motion of a system of two bodies joined by a string
4. To solve problems in which application of Newton's laws leads to two or three simultaneous linear equations involving unknown forces or accelerations

E. Work and the work-energy theorem
  1. The definition of work so that students can:
    a. Use integration to calculate the work performed by a force F(x) on a body which undergoes a specified displacement in one dimension
    b. Use the scalar product operation to calculate the work performed by a specified constant F on a body which undergoes a displacement in a plane
    c. Describe qualitatively, with the aid of sketches, how one may calculate the work performed on a body by a nonconstant force and calculate the work performed by such a force in a case where it acts always parallel or perpendicular to the path of the body
  2. The work-energy theorem so that students can:
    a. State the theorem precisely and prove it for the case of motion in one dimension
    b. Apply the theorem to determine the change in a body's kinetic energy and speed which results from the application of specified forces, or to determine what force is required in order to bring a body to rest in a specified distance

F. Conservative forces and potential energy
  1. The concept of a conservative force so that students can:
    a. State two alternative definitions of "conservative force", and explain why these definitions are equivalent
    b. Describe two examples each of conservative forces and nonconservative forces
  2. The concept of potential energy so that students can:
    a. State the general relation between force and potential energy, and explain why potential energy can be associated only with conservative forces
    b. Calculate a potential energy function associated with a specified one-dimensional force F(x)
    c. Given the potential energy function U(x) for a one-dimensional force, calculate the magnitude and direction of the force
    d. Write down expressions for the force exerted by an ideal spring and for the potential energy stored in a stretched or compressed spring

G. Conservation of energy
  1. The concepts of mechanical energy and of total energy so that students can:
    a. State, prove, and apply the relation between the work performed on a body by nonconservative forces and the change in a body's mechanical energy
    b. Describe and identify situations in which mechanical energy is converted to other forms of energy
    c. Analyze situations in which a body's mechanical energy is changed by friction or by a specified externally applied force

2. Conservation of energy so that students can:
    a. Identify situations in which mechanical energy is or is not conserved
    b. Apply conservation of energy in analyzing the motion of bodies which are moving in a gravitational field and are subject to constraints imposed by strings or surfaces
    c. Apply conservation of energy in analyzing the motion of bodies which move under the influence of springs or other specified one-dimensional forces
3. To recognize and solve problems which call for application both of conservation of energy and Newton's laws

H. Power

The definition of power so that students can:
    a. Calculate the work performed by a force which supplies constant power, or the average power supplied by a force which performs a specified amount of work
    b. Prove that the relation $P = \vec{F} \cdot \vec{v}$ follows from the definition of work, and apply this relation in analyzing particle motion

I. Center of mass

1. The technique for finding center of mass so that students can:
    a. Identify by inspection the center of mass of a body which has a point of symmetry
    b. Locate the center of mass of a system consisting of two such bodies
    c. Use integration to find the center of mass of a thin rod of nonuniform density, of a plane lamina of uniform density, or of a solid of revolution of uniform density
2. To state, prove, and apply the relation between center of mass acceleration and net external force for a system of particles
3. To define center of gravity and to use this concept to express the gravitational potential energy of a rigid body in terms of the position of its center of mass

J. Linear momentum and collisions

1. The relation between linear momentum and force so that students can:
    a. Explain how linear momentum conservation follows as a consequence of Newton's third law for an isolated system
    b. State and apply the relations between linear momentum and center of mass motion for a system of particles
    c. Define impulse, and prove and apply the relation between impulse and momentum
    d. Calculate what force is required in order to hold fixed a body which is emitting, absorbing, or reflecting particles at a specified rate
2. Linear momentum conservation so that students can:
    a. Analyze situations in which two bodies are pushed apart by a spring or other agency, and calculate how much energy is released in such a process

  - b. Analyze collisions of particles in one or two dimensions to determine unknown masses or velocities, and calculate how much kinetic energy is lost in a collision
  - c. Determine the acceleration of a body which is emitting, absorbing, or reflecting particles at a specified rate
3. Frames of reference so that students can:
   - a. Analyze the uniform motion of a particle relative to a moving medium such as a flowing stream
   - b. Transform the description of a collision or decay process to or from a frame of reference in which the center of mass of the system is at rest

K. Torque and rotational statics
1. The concept of torque so that students can:
   - a. Calculate the magnitude and sense of the torque associated with a given force
   - b. Calculate the torque on a rigid body due to gravity
2. To analyze problems in statics so that students can:
   - a. State the conditions for translational and rotational equilibrium of a rigid body which is subject to three or four coplanar forces

L. Rotational kinematics
1. The analogy between translational and rotational kinematics so that students can write down and apply relations among the angular acceleration, angular velocity, and angular displacement of a body which rotates about a fixed axis with constant angular acceleration
2. To use the right hand rule to associate an angular velocity vector with a rotating body

M. Moment of inertia
1. A qualitative understanding of moment of inertia so that students can determine by inspection which of a set of symmetric bodies of equal mass has the greatest moment of inertia
2. Skill in computing moments of inertia so that students can find the moment of inertia of:
   - a. A collection of point masses lying in a plane about an axis perpendicular to the plane
   - b. A thin rod of uniform density about an arbitrary axis perpendicular to the rod
   - c. A thin cylindrical shell about its axis, or a body which may be viewed as being made up of coaxial shells
3. State and apply the parallel-axis theorem

N. Rotational Dynamics
1. The dynamics of fixed-axis rotation so that students can:
   - a. Describe in detail the analogy between fixed-axis rotation and straight-line translation
   - b. Determine the angular acceleration with which a rigid body is accelerated about a fixed axis when subjected to a specified external torque or force

    c. Apply conservation of energy to problems of fixed-axis rotation
    d. Analyze problems involving strings and massive pulleys
2. The motion of a rigid body along surface so that students can:
    a. Write down and justify the relation between linear and angular velocity, or between linear and angular acceleration, for a body of circular cross-section that rolls without slipping along a fixed plane, and determine the velocity and acceleration of an arbitrary point on such a body
    b. Apply the equations of translational and rotational motion simultaneously in analyzing rolling without slipping
    c. Calculate the total kinetic energy of a body which rolls without slipping and apply energy conservation in analyzing such motion

O. Angular momentum
1. Use of the vector cross product and the right-hand rule so that students can:
    a. Calculate the torque of a specified force about an arbitrary origin
    b. Calculate the angular momentum vector for a moving particle
    c. Calculate the angular momentum vector for a rotating rigid body in simple cases where this vector lies parallel to the angular velocity vector
2. Angular momentum conservation so that students can:
    a. State the relation between net external torque and angular momentum, and identify situations in which angular momentum is conserved
    b. Analyze problems in which the moment of inertia of a body is changed as it rotates freely about a fixed-axis

P. Oscillations
1. The kinematics of simple harmonic motion so that students can:
    a. Sketch or identify a graph of displacement as a function of time, determine from such a graph the amplitude, period and frequency of the motion, and write down an appropriate expression of the form $A \sin wt$ or $A \cos wt$ to describe the motion
    b. Identify points in the motion where the velocity is zero or achieves its maximum positive or negative value, and find an expression for velocity as a function of time
    c. State and prove the relation between acceleration and displacement in simple harmonic motion, and identify points in the motion where the acceleration is zero or achieves its greatest positive or negative value
2. The dynamics of oscillating systems so that students can:
    a. Recognize that a system that obeys a differential equation of the form $d^2 x/dt^2 = -w^2 x$ must execute simple harmonic motion, and determine the frequency and period of such motion
    b. Derive and apply the expression for the period of oscillation of a mass on a spring, and analyze problems in which a mass hangs from a spring and oscillates vertically

    c. Determine the period of oscillation for systems involving series or parallel combinations of identical springs, or springs of differing lengths
    d. Derive and apply the expression for the period of a simple pendulum and state what approximation must be made in deriving it
    e. Analyze the motion of a torsional pendulum or physical pendulum in order to determine the period of small oscillations
  3. The applications of energy considerations in analyzing oscillating systems so that students can:
    a. State how the total energy of an oscillating system depends on the amplitude of the motion, and identify points in the motion where this energy is all potential or all kinetic
    b. Calculate the kinetic and potential energies of an oscillating system as functions of time, sketch or identify graphs of these functions, and prove that the sum of kinetic and potential energy is constant
  4. A qualitative understanding of resonance so that students can identify situations in which a system will resonate in response to a sinusoidal external force

Q. Gravitation and planetary motion
  1. Newton's law of universal gravitation so that students can:
    a. Determine the force which one spherically symmetric mass exerts on another and determine the strength of the gravitational field at a specified point outside a spherically symmetric mass
    b. Derive an expression for the potential energy of a system of two bodies interacting gravitationally, and explain why it is reasonable for this quantity to be negative
  2. The motion of a body in a circular orbit under the influence of gravitational forces so that students can:
    a. Derive expresssions for the speed and period of revolution in such an orbit, and prove that Kepler's third law must hold for this special case
    b. Derive and apply the relations among kinetic energy, potential energy, and total energy for such an orbit
  3. The general motion of a body in a gravitational field so that students can:
    a. State Kepler's three laws of planetary motion and use them to describe in qualitative terms the motion of a body in an elliptic orbit
    b. Apply angular momentum conservation and energy conservation to relate the speeds of a body of the two extremes of an elliptic orbit
    c. Apply energy conservation in analyzing the motion of a body which is projected straight up from a planet's surface or which is released from rest far above the surface of a planet

R. Charge, field, and potential
  1. The concept of electric field so that students can:
    a. Define it in terms of the force on a test charge
    b. Calculate the magnitude and direction of the force on a positive or negative charge placed in a specified field

c. Given a diagram on which an electric field is represented by flux lines, determine the direction of the field at a given point, identify locations where the field is strong and where it is weak, and identify where positive or negative charges must be present

2. The concept of electric potential so that students can:

a. Calculate the electrical work done on a positive or negative charge which moves through a specified potential difference

b. Given a sketch of equipotentials for a charge configuration, determine the direction and approximate magnitude of the electric field at various positions

c. Apply conservation of energy to determine the speed of a charged particle which has been accelerated through a specified potential difference

d. Calculate the potential difference between two points in a uniform electric field, and state which is at the higher potential

e. Given electric field strength as a function of position along a line, use integration to determine electric potential as a function of position

f. State the general relation between field and potential, and define and apply the concept of a conservative electric field

S. Field and potential of point charges

1. Coulomb's law and the principle of superposition so that students can:

a. Determine the force which acts between two specified point charges, and describe the electric field of a single point charge

b. Use vector addition to determine the electric field produced by two or more point charges

2. The potential function for a point charge so that students can:

a. Determine the electric potential in the vicinity of one or more point charges, and calculate how much work is required to move a test charge from one location to another in the field of fixed point charges

b. Calculate the electrostatic potential energy of a system of two or more point charges, and calculate how much work is required to move a set of charges into a new configuration

T. Fields of charge distributions

1. To use the principle of superposition to calculate by integration:

a. The electric field of a straight uniformly charged wire

b. The electric field or potential of a thin ring of charge on the axis of the ring

c. The electric potential of a uniformly charged disk on the axis of the disk

2. The fields of highly symmetric charge distributions so that students can:

a. Describe the electric field of an infinite uniformly charged plane, a long uniformly charged wire or thin cylindrical shell, or a thin spherical shell

    b. Use superposition to determine the fields of parallel charged planes, coaxial cylinders, or concentric spheres
    c. Derive expressions for electric potential as a function of position in the above cases
  3. The relation between field and flux so that students can:
    a. Calculate the flux of a uniform electric field through an arbitrary surface
    b. Calculate the flux of $\vec{E}$ through a curved surface when $\vec{E}$ is uniform in magnitude and perpendicular to the surface
    c. Calculate the flux of $\vec{E}$ through a rectangle when E is perpendicular to the rectangle and a function of one coordinate only
    d. State and apply the relation between flux and lines of force
  4. Gauss's law so that students can:
    a. State the law in integral form
    b. Apply the law, along with symmetry arguments, to determine the electric field near a large uniformly charged plane, inside or outside a uniformly charged long cylinder or cylindrical shell, and inside or outside a uniformly charged sphere or spherical shell

U. Current and resistance
  1. The definition of electric currents so that students can relate the magnitude and direction of the current in a wire or ionized medium to the rate of flow of positive and negative charge
  2. Conductivity, resistivity, and resistance so that students can:
    a. Write down the relation between electric field strength and current density in a conductor, and describe qualitatively, in terms of the drift velocity of electrons, why such a relationship is plausible
    b. Derive an expression for the resistance of a resistor of uniform cross-section in terms of its dimensions and the conductivity of the material from which it is constructed, and apply this result in comparing current flow in resistors of different material or different geometry
    c. Derive and apply the expression for the rate at which heat is produced when current passes through a resistor

V. Direct-current circuits
  1. The behavior of series and parallel combinations of resistors so that students can:
    a. Identify on a circuit diagram resistors which are in series or in parallel
    b. Determine the ratio of the voltages across resistors connected in series or the ratio of the currents through resistors connected in parallel
    c. Calculate the equivalent resistance of two or more resistors connected in series or in parallel, or of a network of resistors which can be broken down into series and parallel combinations
    d. Calculate the voltage, current, and power dissipation for any resistor in such a network of resistors connected to a single battery

2. The properties of ideal and real batteries so that students can:
    a. Calculate the terminal voltage of a battery of specified emf and internal resistance from which a known current is flowing
    b. Calculate the rate at which a battery is supplying energy to a circuit or is being charged up by a circuit
    c. State what external resistance draws maximum power from a battery of specified internal resistance, and apply this result in in solving problems involving one or more resistors connected to a single battery
3. The application of Ohm's law and Kirchoff's rules to direct-current circuits in order to:
    a. Determine a single unknown current, voltage, or resistance
    b. Set up and solve simultaneous equations to determine two unknown currents
4. The construction and properties of voltmeters and ammeters so that students can:
    a. State whether the resistance of each is high or low, and assess qualitatively the effect of finite meter resistances on a circuit into which these meters are connected
    b. Given a galvanometer of specified resistance and full-scale deflection, choose an appropriate series or shunt resistance to create a voltmeter or ammeter with a specified full-scale deflection

W. Electrostatics with conductors
1. The nature of electric fields in and around conductors so that students can:
    a. Explain the mechanism responsible for the absence of electric field inside a conductor
    b. Explain why a conductor must be an equipotential, and apply this principle in analyzing what happens when conductors are joined by wires
    c. Prove that all excess charge on a conductor must reside on its surface and that the field outside the conductor must be perpendicular to the surface
    d. Prove and apply the relation between the surface charge density on a conductor and the electric field strength near its surface
2. Induced charge and electrostatic shielding so that students can:
    a. Describe qualitatively the process of charging by induction
    b. Describe the distribution of induced charge on a conducting slab located between charged parallel plates or on a conducting spherical shell surrounding a point charge, and sketch electric field lines for such configurations
    c. Explain qualitatively why there can be no electric field in a charge-free region completely surrounded by a single conductor, and recognize consequences of this result
    d Explain qualitatively why the electric field outside a closed conducting surface cannot depend on the precise location of charge in the space enclosed by the conductor, and identify consequences of this result

Physics 421
GRADE TWELVE

X. Capacitors
   1. The definition of capacitance so students can relate stored charge and voltage for a capacitor
   2. The physics of the parallel-plate capacitor so that students can:
      a. Describe the electric field inside the capacitor, and relate the strength of this field to the potential difference between the plates and to the density of charge on the plates
      b. Derive an expression for the capacitance of a parallel-plate capacitor
      c. Describe how the insertion of a dielectric between the plates of a charged parallel-plate capacitor affects its capacitance and the field strength and voltage between the plates
      d. Analyze situations in which a conducting slab is inserted between the plates of a capacitor
   3. Cylindrical and spherical capacitors so that students can:
      a. Describe the electric field inside each
      b. Derive an expression for the capacitance of each
   4. Energy, work, and force in connection with parallel-plate capacitors so that students can:
      a. Derive expressions for the energy stored in a capacitor and for the energy density in the field between the plates
      b. Analyze situations in which capacitor plates are moved apart or moved closer together, or in which a conducting slab is inserted between capacitor plates, either with a battery connected between the plates or with the charge on the plates held fixed

Y. Capacitors in circuits
   1. The behavior of capacitors connected in series or in parallel so that students can:
      a. Calculate the equivalent capacitance of a series or parallel combination
      b. Describe how stored charge is divided between two capacitors connected in parallel
      c. Determine the ratio of voltages for two capacitors connected in series
   2. To calculate the voltage or stored charge, under steady-state conditions, for a capacitor connected to a circuit consisting of a battery and resistors
   3. The discharging or charging of a capacitor through a resistor so that students can:
      a. Calculate the time constant of the circuit
      b. Sketch or identify graphs of stored charge or voltage for the capacitor, or of current or voltage for the resistor, and indicate on the graph the significance of the time constant
      c. Write down expressions to describe the time dependence of the stored charge or voltage for the capacitor, or of the current or voltage for the resistor
   4. Skill in analyzing the behavior of circuits containing several capacitors and resistors so that students can:
      a. Determine voltages and currents immediately after a switch has been closed and also after steady-state conditions have been established

- b. Identify graphs which correctly indicate how voltages and currents vary with time

Z. Forces on charges and currents
- 1. The force experienced by a charged particle in a magnetic field so that students can:
  - a. Calculate the magnitude and direction on the force in terms of q, $\vec{v}$, and $\vec{B}$, and explain why the magnetic force can perform no work
  - b. Deduce the direction of magnetic field $\vec{B}$ from information about the forces experienced by charged particles moving through the field
  - c. State and apply the formula for the radius of the circular path of a charge which moves perpendicular to a uniform magnetic field, and derive this formula from Newton's second law and the magnetic force law
  - d. Describe the most general path possible for a charged particle moving in a uniform magnetic field
  - e. Describe quantitatively under what conditions particles will move with constant velocity through crossed electric and magnetic fields
- 2. The force experienced by a current in a magnetic field so that students can:
  - a. Calculate the magnitude and direction of the force on a straight segment of current-carrying wire in a uniform magnetic field
  - b. Indicate the direction of magnetic forces on a current-carrying loop of wire in a magnetic field
  - c. Calculate the magnitude and direction of the torque experienced by a rectangular loop of wire carrying a current in a magnetic field

AA. Production of magnetic fields
- 1. The magnetic field produced by a long straight current-carrying wire so that students can:
  - a. Calculate the magnitude and direction of the field at a point in the vicinity of such a wire
  - b. Calculate the force of attraction or repulsion between two long current-carrying wires
- 2. The Biot-Savart law so that students can:
  - a. Deduce the magnitude and direction of the contribution to the magnitude field made by a short straight segment of current-carrying wire
  - b. Derive and apply the expression for the magnitude of $\vec{B}$ on the axis of a circular loop of current
- 3. Skill in applying Ampere's law so that students can:
  - a. Use Ampere's law plus appropriate symmetry arguments to derive an expression for the magnitude of $\vec{B}$ inside or outside a solid or hollow long cylinder carrying a current of uniform density

    b. Use Ampere's law to derive an approximate expression for the magnitude of $\vec{B}$ inside a very lon solenoid or inside a toroidal solenoid
  4. Skill in applying the superposition principle so that students can determine the magnetic field produced by combinations of the configurations listed above

BB. Electromagnetic induction
  1. The concept of magnetic flux so that students can:
    a. Calculate the flux of a uniform magnetic field through a loop of arbitrary orientation
    b. Use integration to calculate the flux of a nonuniform magnetic field, whose magnitude is a function of one coordinate, through a rectangular loop perpendicular to the field
  2. Faraday's law and Lenz's law so that students can calculate the magnitude and direction of the induced emf and current:
    a. In a loop of wire that is being pulled into or out of a uniform magnetic field
    b. In a loop of wire placed in a spatially uniform magnetic field whose magnitude is a specified function of time
    c. In a loop of wire that rotates at a constant rate about an axis perpendicular to a uniform magnetic field
  3. Skill in analyzing the forces that act on induced currents so that students can solve simple problems involving the mechanical consequences of electromagnetic induction
  4. The concept of inductance so that students can:
    a. Calculate the magnitude and sense of the emf in an inductor through which a specified changing current is flowing
    b. Derive and apply the expression for the self-inductance of a long solenoid

GRADED COURSE OF STUDY

SCIENCE

EVALUATION

1. Teacher-made criterion reference tests
2. Teacher-made science essay tests
3. Commercial textbook related tests
4. Periodic system-wide evaluation of the science program
5. Formalized lab grading with prespecified criteria where appropriate
6. Direct observation of student involvement in all class and lab activities